



State University of New York at Fredonia  
Department of Mathematical Sciences

CERTIFICATION OF PROJECT WORK

We the undersigned, certify that this project entitled Exploring Everyday math without using Technology: A study of high school students using mental math and estimation to solve everyday mathematical tasks by Karla Mead, Candidate for the degree of Master of Science in Education, Mathematics Education (7-12), is acceptable in form and content and demonstrates a satisfactory knowledge of the field covered by this project.

  
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## INTRODUCTION

This study examines the skills people have with using mental computation. Mental computation is a skill that is used less and less with the advent of technology. Most people are more likely to turn to a calculator or cell phone in order to compute simple mathematical problems than trying to use mental computation. Participants were challenged with a variety of tasks but they were only allowed to use mental computation in order to complete them.

With the advent of technology teaching any subject has vastly changed in the last 50 years. This is especially true for the mathematics classroom. However, as useful as technology is in the classroom it also has its drawbacks. People need to recognize when they are using technology as a tool to help them with learning and when they are relying on it to do everything for them. The thought processes of mental computation seem to be falling to the wayside as more and more people assume that because we have the technology we should not have to bother with exercising our minds with simple tasks. This study was created to determine how two different generations compared when solving everyday mathematical problems without using technology. The purpose of this literature review is to examine the pros and cons of using technology in the classroom and how it impacts people's attitudes towards mental computation.

It is extremely frustrating when you are checking out at a store and the cashier has no idea how to handle giving you your cash back if they make a mistake when punching in the amount given. The cashier has a look of panic on their face and when attempting to help them, they are unsure whether or not to believe you. As a little girl my mother made sure that I was able to count change back, correctly, so that this situation would not be a problem. However, it seems that with today's technology many people consider this skill to be unnecessary and inconvenient to learn.

I am curious as to how two different generations fare when it comes to mental computation. Mental computation is an important set of skills that should not fall into a decline out of laziness. This study focused on how different generations view mental computation and the skills associated with it.

*It is hypothesized that 12th grade students will have difficulty computing everyday mathematics tasks without the use of technology. Students will struggle with mental computation, estimation, and counting techniques that are part of everyday mathematics. Moreover, adult participants will be more adept at handling the tasks assigned to them.*

Mathematics is a subject that requires practice and mental computation is a skill that needs to be used often, in order for them to become easier. Unfortunately most people seem to turn to technology to figure out the answer instead of taking the time to solve the problem on their own.

### **LITERATURE REVIEW**

This literature review explores the impact of technology on the mathematics classroom. Ethnomathematics is also reviewed and how there needs to be a connection between the students' culture and mathematics in order to garner students' interest. There have been studies conducted concerning the pros and cons to introducing technology too early and the lasting effects of it in the classroom. This literature review also examines mental computation and student attitude towards it. Finally, the literature review considers technology in the mathematics classroom and whether it is an asset or a limitation to student learning.

### *Ethnomathematics*

Ethnomathematics is a way of thinking about how mathematics and different cultures are intertwined. These cultures may simply be the difference between “scholarly mathematics” and “practical mathematics” (D’Ambrosio, 1985, p. 44). Scholarly mathematics are considered the mathematics that the Greeks deemed necessary for the “ideal education”, while practical mathematics were considered the mathematics needed for manual workers (D’Ambrosio, 1985, p. 44). Through the centuries these mathematical ideas have begun to intertwine until we have what is now referred to as “academic mathematics” (D’Ambrosio, 1985, p. 45). As technology has become more prevalent, though, people rely on it to do the simple tasks for them instead of trying on their own. This reliance may stem from the fact that schools do not teach mathematics using Ethnomathematics. Students do not recognize the significance of mathematics to the culture and world around them and therefore consider it irrelevant.

Ethnomathematics is defined as “the relationship between culture and mathematics” by Ubiratan D’Ambrosio (2001, p. 308). The goal of teaching mathematics using Ethnomathematics is that the teacher is showing her students that their culture and mathematics are connected to each other; that math is not just a European concept (D’Ambrosio, 2001).

D’Ambrosio claims:

We must teach children to value diversity in the mathematics classroom and to understand both the influence that culture has on mathematics and how this influence results in different ways in which mathematics is used and communicated. (p. 309)

D’Ambrosio is saying that in order for students to connect to mathematics on a deeper level beyond just numbers, teachers need to talk about the origins of the concepts and how different cultures used them. Unfortunately with standardized testing becoming a significant part of classroom assessments, many teachers may feel that they do not have the time to show students

more than just the basic concepts and hope that their students will understand and learn enough in order to pass the test. However, if students are unable to make connections concerning mathematics on a deeper level they will be unable to do more than have a superficial understanding of the concepts. This would become a problem when they need to remember these same concepts in later mathematics courses and are unable to recall them.

Ethnomathematics discusses two different types of mathematics as thought about by the Greeks and in today's world there are similar ideas.

According to Tine Wedege (2010) real world mathematics is broken up into two categories. The first is "knowledge developed in everyday life" and the second is "knowledge wanted in everyday life" (Wedege, 2010, p. 34). He states that the first type of real world mathematics is the mathematics that people develop because they have to use it. The second type of real world mathematics is the mathematics that people should know because it is considered to help them function in life. The first type is generally learned outside of the classroom while the second type is generally learned inside of it (Wedege, 2010). Unfortunately, the first type of real world mathematics tends to be forgotten as the second type is learned. According to Wedege (2010) a study that was performed in Sweden showed that adult learners' mathematical skills were "algorithmised through schooling and their problem solving ability decreased" (p. 37). Instead of thinking outside of the box in order to find different ways to solve a problem, students just turn to the algorithms they learned in the classroom and give up when they do not work. This would not be a problem except that mathematics in the real world is often not as simple as mathematics in the classroom. Using a skill such as mental computation will help strengthen both types of real world mathematics.

### *Mental Computation*

Teaching mathematics in a way that relates to the culture and world around us would help students better connect to the idea of mental computation. Mental computation is still an important skill for students to learn today. As Annaliese Caney notes, teaching students mental computation can give one valuable insight into their thought processes. Caney (2004) sat down with students from various grades and asked them a variety of simple addition, subtraction, and multiplication questions. After the students thought about them and gave her their answers she would ask them how they arrived at the answer. While some of the answers were wrong, once the student explained what they did, they would realize their mistake and correct their answer (Caney, 2004). Having students explain their thought processes to the teacher helps that teacher come up with different methods for ensuring that all of her students are capable of learning different mathematics concepts. However, mental computation is starting to decline as people start turning to technology to do the simple computations for them.

Mental computation is a skill that requires practice in order for a person to become better skilled at it (Pyke & LeFevre, 2011). Along with this sentiment is that if someone is proficient at mental computation they will be able to obtain an answer quicker than someone who relies on a calculator. Pyke and LeFevre claim that someone who uses mental computation is more engaged in their own learning “due to increased attention, effort, and engagement in learning” (p. 608). The student who used mental computation to learn would be able to more readily relate the problem with the answer, as opposed to the student who used their calculator to obtain the answer. By solely using the calculator that student would be able to find the correct answer but would be less likely to retain the information for later use.

Teaching mental math teaches students the importance of estimation. As Rheta Rubenstein (2001) observes, people use estimation in the real world. Turning to technology to do something that you could easily compute yourself using estimation takes longer and wastes your time. Students need to learn mental computation strategies so that they will not become overly dependent on calculators and will realize that they have more than one possible way to figure something out. Mental computation also allows for a greater classroom discussion about how an answer was obtained. A student can explain to the class what their thought processes were and the other students can offer suggestions for future uses. Using mental computation a student can not just say “I plugged the problem into the calculator and the calculator told me...”. Also by not solely relying on a calculator students may also be able to correct their answers if they feel the calculator did not arrive at the correct answer. Teachers must now determine how to intertwine both mental computation and technology in the classroom.

### ***The Pros and Cons of Technology in the Classroom***

While technology use in the classroom can be a huge advantage, especially when the teacher is trying to show students more complex mathematical concepts, it can also be detrimental to students’ learning when it becomes more than a tool. As technology becomes more prevalent in people’s everyday lives some researchers have found that it has both positive and negative impact in the classroom (Graff & Leiffer, 2005; Khan, 2009; Santana, 2008). Finding the pros and cons of using calculators in the mathematics classroom is not a new topic to be researched and it is much contested. Some researchers find that using calculators helps students with higher level concepts and helps them more than hurts them (Freiberg, 2012; Pyke & LeFevre, 2011).

According to Pyke & LeFevre (2011) when students try to first recall an answer from memory as opposed to letting the calculator do the work, the students are more engaged in learning and are more likely to remember the answer for future problems. The calculator may give them the correct answer but they have not learned anything from using it about how to solve the problem. If we teach students by letting them think through the solutions for themselves they are more likely to recall the problem and solution than if we just give them the answer. This type of learning process is called *self generated* (Pyke & LeFevre, 2011).

One disadvantage to using calculators in the classroom is that some students become dependent on them for answers. Graff and Leiffer (2005) bring to attention that many of the incoming students in college have weaknesses where mathematics is concerned and that these weaknesses cause errors not in the higher level mathematics but the basic mathematics. Students struggle with the addition, subtraction, multiplication, and division components of problems as opposed to the higher level concepts. Students also have trouble comprehending that their answers are wrong if those are the answers the calculator gave them (Graff & Leiffer, 2005). As people become more dependent on technology they start to lose the ability to perform simple tasks without it.

A paper written by Julian Parham Santana (2008) discusses the belief that people are becoming too reliant on technology, for the worse, and questions what would happen if there was a catastrophe that prevented people from using technology. He writes about how people prefer the calculator to do the work for them instead of trying to figure it out first and using the calculator as a last resort or a device to check our answers. This dependence on calculators will cause issues as students begin to take higher level mathematics courses and are unable to perform at the required level because they are unable to compute or even relate to mathematics



that cannot just be entered into the calculator for an answer (Santana, 2008). Counting change back to a customer without using either a calculator or the cash register itself is almost unheard of in this day and age. This is a worrying trend because counting back change is a simple enough procedure but we as a society are becoming too lazy to even contemplate something that we consider too hard and pointless now that we have machines that do it for us. While there are many concerns about using technology in the classroom, there are many positive arguments to use it.

According to Graff & Leiffer (2005) some of the positive aspects of technology use are that students are much more effective at communicating with both their professors and their fellow classmates since email and cell phones make getting in touch much simpler. Students are also much more adept at using technology because they have been introduced to it earlier and have been using it for most of their lives. However, some of the negative impacts from technology use is that students have a short attention span and that as our society is shifting from a society that reads books to a society that watches television, our vocabulary is also starting to diminish (Graff & Leiffer, 2005). As texting language becomes more popular not only is our vocabulary starting to diminish but people's abilities to spell, use grammar correctly, and even write full sentences properly is also starting to shrink. Teachers should also be aware that while there are positive reasons for using technology in the classroom, some students will take advantage of it.

Many students today expect to receive good grades for minimum effort on their part and as they begin college they realize too late that this is not an acceptable practice (Graff & Leiffer, 2005). However, in the eyes of the students a bad grade is never the fault of the student who received it, it is the fault of the teacher, university, or anyone else the student can blame. As

some students realize that a good grade is not going to come easy, they instead turn to cheating in order to obtain it. With the dawn of technology cheating is becoming not only easier to accomplish but sadly also more prevalent (Graff & Leiffer, 2005). There are many different means for students to use technology in order to cheat.

The different ways students can cheat and use technology for the worse is examined by Kahn (2009). He discusses calculators that have massive memory banks and wireless settings so that students can talk to each other and share data. Students can use online resources to either plagiarize someone else's work or even to buy a pre-written paper so that they will not have to do the work at all. Kahn discusses how it is up to the teacher to catch these acts while they are happening to ensure that students realize that what they are doing is unethical. However, he notes that the one factor that these other papers fail to capture though, are the students' thoughts on why they cheat and why they believe it to be an acceptable behavior. He states that "Academic institutions need to understand what is affecting students' attitude towards e-cheating." (p. 11). Until we as a society can stop the permissive attitude towards cheating that is beginning to occur we will never be able to show students that what they believe is acceptable, because technology gives them the means to do it, is in fact unacceptable. Before using any technology in the classroom, educators should weigh the pros and cons. While it can be extremely useful, we should make sure that the technology is being used as a tool as opposed to doing the work for the students.

### ***Technology and the Mathematics Classroom***

Numerous studies have been conducted to determine whether technology in the mathematics classroom is a hindrance or a valuable tool that should be utilized whenever possible. Research has determined that technology in the classroom can only help students when learning mathematical concepts by improving their confidence and motivating them (Li, 2007). Other studies have asked

teachers about their use of technology in the classroom (Brown, Karp, Petrosko, Jones, Beswick, Howe, & Zwagnig, 2007; Li, 2007). Different countries have different beliefs regarding calculator use in the classroom (Tarr, Uekawa, Mittag, & Lennex, 2000). Technology does have a place in the classroom but it is important for both students and teachers to recognize when it is becoming a device that does the work for the student or a tool that helps the student perform a task.

Teachers and students view technology with different attitudes. According to Li (2007), teachers see it as a tool that can be useful in their classroom but if a class is not performing well they will withhold it so they can focus on the problem area without any distractions. Students, however, embrace technology stating four reasons for its necessity: “Increased efficiency, pedagogy, preparing for the future, and increased motivation and confidence” (Li, 2007, p. 383-387). Some of their reasoning is sound such as technology provides them with resources to better understand what they are learning, it is a more engaging interface than a teacher, and it helps them by motivating them and giving them more confidence in the classroom. However, some of the reasons why students prefer technology in the classroom are problematic. Li quoted one student as saying “our world is turning itself into a world that is relying on machines and technology; we need to know how to use it so we can advance” (p. 387). Relying on anything to do the work for someone is never a good idea. A balance needs to be found between using a tool and solely expecting it to do the work for someone. While people do need to know how to use technology in order to advance they should not make the mistake of expecting it to give them all of the answers. This train of thought leads into another student’s quote, “...The material in math would be impossible to learn if I didn’t have my graphing calculator” (Li, 2007, p. 387). This statement makes it sound as though the student does not attempt any other method of solving mathematical problems first before turning to his calculator to do the work for him.

Technology use in the classroom is dependent on the teacher’s beliefs concerning the subject matter, the students, and whether they think the technology will contribute to the students’

understanding. The more familiar the teacher is with technology in the classroom the more likely they are to turn to it. Brown, Karp, Petrosko, Jones, Beswick, Howe, and Zwagnig (2007) sent out surveys to “26 high schools, 29 middle schools, and 86 elementary schools” in a large metropolitan area (Brown, et al., 2007, p.105). These surveys were distributed to the mathematics teachers at the high schools and middle schools, while teachers were selected at random in the elementary schools (Brown et al., 2007). The teachers were asked questions about their beliefs concerning calculator use in their classrooms. The researchers identified four factors that teachers consider when it comes to calculator use in their classrooms: “Catalyst beliefs, teacher knowledge, crutch beliefs, and teacher practices” (p. 110). When it comes to calculator use in the classroom there needs to be a balance between the calculator being a catalyst and a crutch. Students should be taught that the calculator is a tool that can help them but not something that will do the work for them. This is where teachers’ beliefs and practices concerning calculator use in the classroom come into effect. Teachers need to be familiar with the technology in order to ensure that their students are still trying and thinking about the problems on their own before they give up and let the calculator solve it for them.

In Brown, et al., (2007), the authors quote J. Fey saying “that it no longer makes sense to focus extended periods of time on a curriculum centered on arithmetic and algebraic algorithms that can be easily done with low cost calculators.” (p. 103). Interestingly, though, Japan requires students to take a “...high school entrance examination. In this examination, calculator use is prohibited” (Tarr, Uekawa, Mittag, & Lennex, 2000, p.148). Tarr, Uekawa, Mittag, and Lennex (2007) researched the calculator usage among students from Japan, Portugal, and the United States. Japan was chosen because it is one of twenty nations that scored considerably higher on the Third International Mathematics and Science Study (TIMSS) than the United States while Portugal was selected because they scored considerably lower. The results were surprising in that there are few countries in the world where students are expected to be able to use mental computation in order to solve mathematical problems instead of using a calculator (Tarr, 2007). In fact, when asked in a

survey, 75% of Japanese students stated that they never use a calculator during their classes. What is even more impressive is that only .37% of Japanese students claim to always use a calculator compared to the 43% of students who always use a calculator in the United States (Tarr, et al., 2007).

While comparing calculator use among students from Japan, Portugal, and the United States, the researchers compared how using a calculator affected the success of the students. In the United States calculator use helped students succeed, while in both Portugal and Japan calculators actually held them back. With the Japanese students “a significant negative coefficient was observed” however, the Portuguese students’ lack of success was far less significant (Tarr, et al., 2007).

Examining this study does beg the question: how much of a catalyst are calculators and how much of a crutch are they? Solving mathematical problems without using technology encourages people to think about different ways to produce an answer.

A group of children vendors in Beirut were studied by Jurdak and Shahin (1999) to determine what mathematical skills they used in the market. The selection of the children was done in two stages. In the first stage 25 children were chosen from two markets. In the second stage 10 children were chosen from the 25 originally chosen children. The children were between 10 and 16 years of age and their number of years they had worked in the markets also varied. In order to obtain the data the researchers observed the children and later interviewed them. The study found that the children street vendors applied three different computational methods in order to conduct their business. These methods were “decomposition, counting up, and repeated grouping.” (p. 160). *Decomposition* breaks up a problem in order to more easily add the components together. It is the same method that young children are taught in the United States when they are first taught addition of larger numbers. The street vendors used the counting up method when they needed to subtract something. Repeated grouping was used for multiplication and is also a similar method to the one which teachers in the US use when multiplication is first introduced. The study noted that the children would apply different methods for computational problems in the workplace and that of a school setting. It also found that

the methods the children used for the workplace were more effective than the methods they used in the classroom.

In our goal to teach children all they need to know in the real world, we need to find a balance between utilizing technology to its fullest potential and ensuring that people are capable of performing tasks without it. There are simple techniques for solving real world problems that do not require turning to technology and it is important that these techniques are taught to the next generation. The following research was designed to determine if people are too dependent on technology in today's world or if they are still capable of solving real world mathematical problems without using technology.

### **EXPERIMENTAL DESIGN**

This experiment was designed to test the hypothesis that participants would struggle with tasks that involve real world mathematics without the help of technology. The tasks that were chosen are activities that can be easily done by using mental computation, estimation, and counting techniques. Each task was evaluated by assessing how close the participant was to either the correct answer or whether their answer fell in a range that was determined based on the activity. Participants were also assessed on how long it took them to complete the task. Participants were given a survey that asked them to walk me through their thought process for each activity.

### **Participants**

This study was conducted in a suburban high school in the northeast and a rural fire department. The high school has approximately 1,665 students between 9th and 12th grades. The school student population is 94% Caucasian, 3% Hispanic, 2% Black, 0.9% Asian, 0.4% Native American or Native Alaskan, 0.3% Asian/Pacific Islander, and 0.1% Multiracial. The participants are in a 12th grade math class. The fire department has

approximately 40 members. Of these members, 36 are males and 4 are females, and the fire department is 100% Caucasian. There were thirty volunteers that participated from a group of high school students and a group of adults. Of the fifteen student participants 14 were Caucasian and one was Asian American. All of the adult participants were Caucasian. The ages of the participants fall between 18 and 90 years old. The volunteer firefighters were chosen to examine the difference between a younger and older generation when solving real world mathematics. The genders of the participants were not recorded as the experiment focused on their ages instead. Written consent was obtained from these participants.

### **Design**

The experiment tested the hypothesis that the younger generation would struggle with everyday mathematics without using technology, while the older generation would be more adept at using mental computation in order to solve the same problems. The experiment was broken up into 4 parts with each station testing a different skill. Participants had to use mental computation to solve mathematic problems that involved addition, subtraction, multiplication, estimation, and percentages. Stations were set up to test the participants as opposed to a formal test because the study was focused on examining how well people are capable of using mental computation. The stations were proctored by my family and me. The survey was included in the packet that each participant was given when they first arrived and asked participants to describe their thought process while they were completing their task. At the end of the experiment participants were asked to list the tasks from most difficult to easiest and explain why.

### **Instrument Items and Justification**

There were four different stations that needed to be completed. Participants were recorded at each station and completed a survey at the end of all four stations. A packet was picked up that had all of the papers that the volunteers would need to complete the stations. Each station had an answer sheet that the participant handed to the proctor of that station and when they completed the station the proctor gave the participant back the answer sheet. Each station was designed to test participants' knowledge of mental computation while completing real world mathematics tasks. The methods used to solve each station are simple computational methods that are starting to be ignored in favor of technology. These stations showed participants that while technology can be a good thing, it is not necessarily needed and should not be used all the time.

The first station tests participants' skills to use estimation in order to buy products without going over a set amount. For this station participants were told that they could only spend a certain amount of money. They were shown products and they "bought" as many products as they could without going over their limit. I hypothesized that this station would not be all that difficult.

The second station tested the participants' ability to estimate discounts on different products. Participants were given 5 amounts and told different percentage discounts for each product. I predicted that participants would struggle with this station due to working with percentages.

At the third station, participants were given a cash box with money but no calculator. Participants were then given a total and handed an amount of money. Participants then had to give the correct change back without relying on a calculator to figure it out for them. This station was designed to determine if participants would be able to find a different method for



giving someone their correct change back. I predicted that this station would be the most difficult of the four. I also hypothesized that the younger generation would have more difficulty with this station than the older generation.

The fourth and final station tested participants' skill to determine a waiter's tip without using a tip calculator. Participants had to find a 20% tip, 15% tip and then they had to double the tax and inform the proctor what percentage tip that was. I predicted that this station would trouble some participants but overall would be relatively easy.

The survey was designed to gain insight into the minds of the participants and understand how they completed each of these stations. Participants explained how they thought through each station and the mental computation methods they used. The last question asked participants to rank the stations according to difficulty and explain their rankings.

Figure 1, on the next page, shows the answer sheets for the stations. Participants handed the proctor the answer sheet for each station and the proctor would give the answer sheet back when the participant had completed the station. Stations 1, 2, and 3 had five problems for the volunteers to solve and station 4 had three problems to solve.

**Station 1**

Shopping

1. Buy all different products to spend between \$18 and \$20.
  
2. Buy all different products to spend between \$23 and \$25. There needs to be two products that have multiples.
  
3. Only buy one product to spend between \$9 and \$10.
  
4. Only buy three products to spend between \$13 and \$15. (Multiples of any of the three products are allowed.)
  
5. Buy 10 products to spend between \$33 and \$35 dollars. But 3 items must be the same and a different 2 items must be the same. (You should have a total of 13 items but 10 different products.)

**Station 3**

Counting Back Change

1. Bill: \_\_\_\_\_  
 Amount Given: \_\_\_\_\_  
 Change: \_\_\_\_\_
  
2. Bill: \_\_\_\_\_  
 Amount Given: \_\_\_\_\_  
 Change: \_\_\_\_\_
  
3. Bill: \_\_\_\_\_  
 Amount Given: \_\_\_\_\_  
 Change: \_\_\_\_\_
  
4. Bill: \_\_\_\_\_  
 Amount Given: \_\_\_\_\_  
 Change: \_\_\_\_\_
  
5. Bill: \_\_\_\_\_  
 Amount Given: \_\_\_\_\_  
 Change: \_\_\_\_\_

**Station 2**

Discount

1. Original Price: \_\_\_\_\_  
 Discount: \_\_\_\_\_  
 New Price: \_\_\_\_\_
  
2. Original Price: \_\_\_\_\_  
 Discount: \_\_\_\_\_  
 New Price: \_\_\_\_\_
  
3. Original Price: \_\_\_\_\_  
 Discount: \_\_\_\_\_  
 New Price: \_\_\_\_\_
  
4. Original Price: \_\_\_\_\_  
 Discount: \_\_\_\_\_  
 New Price: \_\_\_\_\_
  
5. Original Price: \_\_\_\_\_  
 Discount: \_\_\_\_\_  
 New Price: \_\_\_\_\_

**Station 4**

Tips

1. 20% Tip  
 Bill: \_\_\_\_\_  
 Tax: \_\_\_\_\_  
 Tip: \_\_\_\_\_
  
2. 15% Tip  
 Bill: \_\_\_\_\_  
 Tax: \_\_\_\_\_  
 Tip: \_\_\_\_\_
  
3. Double Tax Tip  
 Bill: \_\_\_\_\_  
 Tax: \_\_\_\_\_  
 Tip: \_\_\_\_\_  
 Percent of Tip: \_\_\_\_\_

*Figure 1. Answer sheets for all four stations.*

**METHODS OF DATA ANALYSIS**

The experiments were designed to assess how participants perform everyday mathematic problems without the use of technology. Participants were assessed on how well and accurately they were able to accomplish these tasks. After the tasks had been completed participants then completed a survey asking them to describe their thought processes during all four stations. The participants were assessed on the following rubric:

	2 Participant gave up and was unable to complete station.	4 Participant attempted to complete station. Had incorrect answers.	6 Participant completed station. Had some correct answers.	8 Participant completed station. Had mostly correct answers.	10 Participant completed station. All answers are correct.
Change Back					
Discount					
Shopping					
Tip					

Each participant received a score out of 10 points for all of the individual stations and then they received an overall score out of 40 points. The scores from the two age groups were compared for each individual station and the overall score.

Score categories were set up based on the total scores of the participants. Participants who scored 37 points or higher were considered “Excellent”. Participants who scored 35 or 36

points were considered to be “Above Average”. Participants who were considered “Average” scored between 30 and 34 points. Participants who are in the category of “Below Average” scored between 25 and 29 points. Participants who were considered “Poor” received a score below 25 points.

Score categories were also set up for each individual station. Participants who received a score of 9 points or higher were considered “Excellent”. Those who had a score of 7 or 8 points were considered “Average”. Participants who are in the category “Below Average” had a score of 5 or 6 points. Those participants who scored 4 points or lower were considered “Poor”.

After the overall scores were inputted, an ANOVA test was completed. An ANOVA test was run on the individual station scores along with a general linear model of score versus station, age group, and participant performed.

## RESULTS

After the completion of this study, four principal results emerged. These results supported the hypothesis to an extent.

- ***Overall, the older participants performed better than the high school students.***

After all of the packets were graded it was concluded that the firefighters had a higher average score than the high school students. The firefighters had an average score of 36.20 points while the high school students had an average score of 27.67 points. (p-value 0.000, F-value 21.92)

- ***There was no significant difference between the two age groups in Station 1 and Station 3.***

The skill tested in Station 1 was using mental computation to add numbers together. Both groups were able to perform the mental computation relatively well. The

firefighters scored higher than the high school students for this station but the difference of the means was 1.2 points. The firefighters had an average of 8.4 while the high school students had an average of 7.2 points. (p-value 0.059, F-value 3.88)

Station 3 tested participants' skill concerning finding a method to correctly give someone the proper change. Both groups were able to successfully use some technique to find the correct change. The firefighters scored higher than the high school students but the difference of the means was 1. The firefighters had an average of 9.6 points while the high school students had an average of 8.6 points. (p-value 0.071, F-value 3.67)

- ***There was a significant difference between the two age groups in Station 2 and Station 4.***

Station 2 tested the volunteers' skill at working with percentages and finding the discounted prices. While the firefighters performed well in this station, the high school students did not. The firefighters had an average score of 9.067 points and the high school students had an average score of 5.4 points. (p-value 0.000, F-value 36.89)

Station 4 also concerned percentages. For this station participants had to find the correct tip. The firefighters performed well in this station but the high school students struggled with it. The firefighters had an average score of 9.0 points and the high school students had an average score of 6.267 points. (p-value 0.001, F-value 16.19)

- ***The older participants used more effective methods concerning percentages than the high school students.***

The difference in skill and methods used between the two age groups with regard to mathematic problems about percentages was quite considerable. The firefighters

were able to clearly state the methods they used to solve mathematic problems in Stations 2 and 4. Many of the high school students used either an ineffective method or stated they did not use any method and simply guessed.

***Result #1: Overall, the firefighters performed better than the high school students.***

Upon analysis of the scores of all four stations it was determined that the adult participants scored higher than the high school students. Figure 2, below, compares the total scores of both groups of participants. While there were some high school students who scored in the same range as the adult participants, there were more who scored lower.

Figure 2 clearly illustrates that while the firefighters' scores had a smaller range, the high school students had a larger range of scores. The highest score received by the firefighters was a 40, while the lowest score was a 32. The highest score the high school students had was a 37, while the lowest score was a 17.



***Figure 2. Box plot of scores for both age groups.***

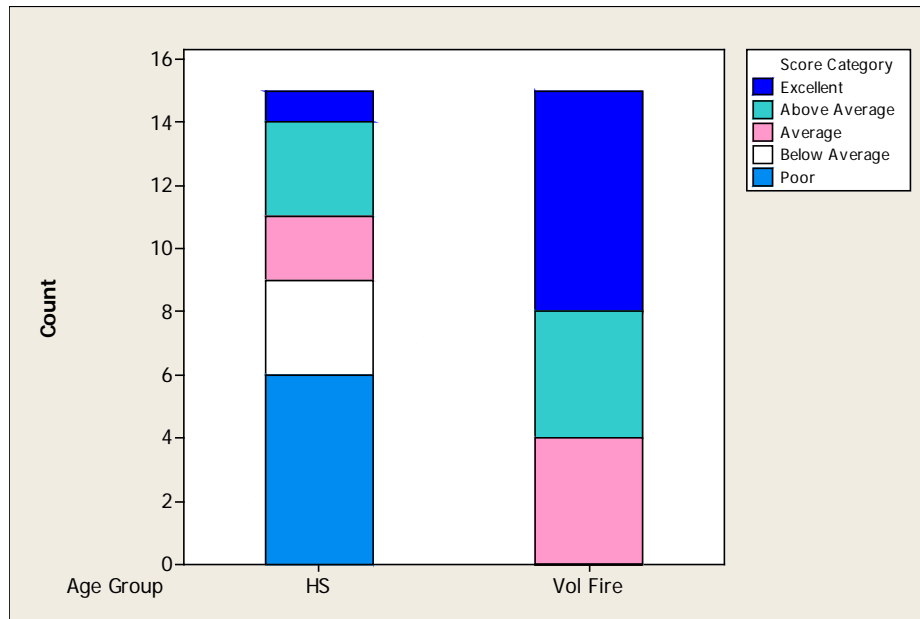
The chart below, Figure 3, shows the differences between the age groups and the mean score for each station. While stations 1 and 3 are relatively close in score, there is an obvious

difference for both stations 2 and 4. The firefighters were reasonably able to solve mathematics problems that involved percentages with almost no difficulty. However, it is clear that the high school students struggled with percentages. Figure 3 also demonstrates that for all of the stations the firefighters average scores were close together. However, the average scores of the high school students were more spread out.



*Figure 3. Comparison of the age groups and their mean scores for each station.*

Figure 4, below, compares the score categories between both age groups. Seven adult participants received an “Excellent” score while only 1 high school student earned a score high enough to be considered “Excellent”. No firefighters earned a score lower than “Average” but 6 high school students earned a score below 25 points which gave them a “Poor”.



**Figure 4.** Comparison of the total scores between the age groups and score categories.

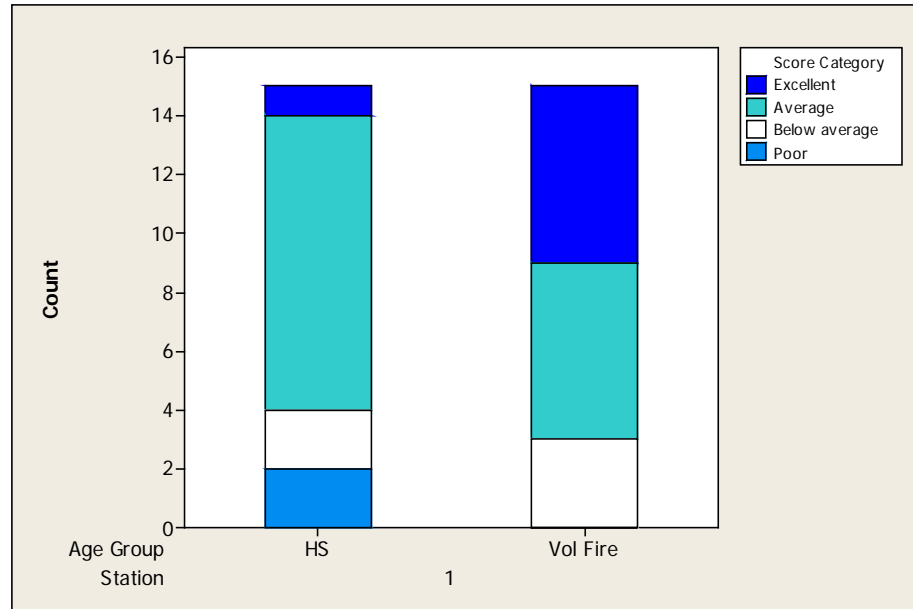
**Result #2:** *There was no significant difference between the two age groups in Station 1 and Station 3.*

Station 1 tested participants’ skill at using mental computation while adding multiple numbers. After an analysis of all four stations was completed it was found that this station was the most difficult station for the firefighters. The average score for the firefighters in this station was 8.4 points. However, the high school students struggled more with this station earning an average score of 7.2 points. After performing an ANOVA test between both age groups, the F-value was 3.88 and the p-value was 0.059. These statistics suggest that both groups of



participants were able to successfully solve problems concerning mental computation and addition without using technology.

Figure 5 shows that 80% of the firefighters were either “Excellent” or “Average”, while 67% of the high school students were “Average”. Two students struggled with this station, but overall the students performed reasonably well.



**Figure 5. Comparison of age groups and score categories for Station 1.**

Station 3 assessed the participants’ skill with giving the correct amount of change. I had hypothesized that Station 3 would be the most difficult for the students to complete. This was the station, however, that the students had the highest average in. The students had an average of 8.4 points, while the firefighters had an average of 9.6 points. By using an analysis of variance (ANOVA) test it was found that the F-value was 3.67 and the p-value was 0.071. These statistics suggest that both age groups are capable of using some technique in order to make change.

As evidenced by Figure 6, Station 3 was the station with the highest number of participants who received an “Excellent”, while only one student received a “Poor”. Three firefighters and five high school students earned an “Average” score.

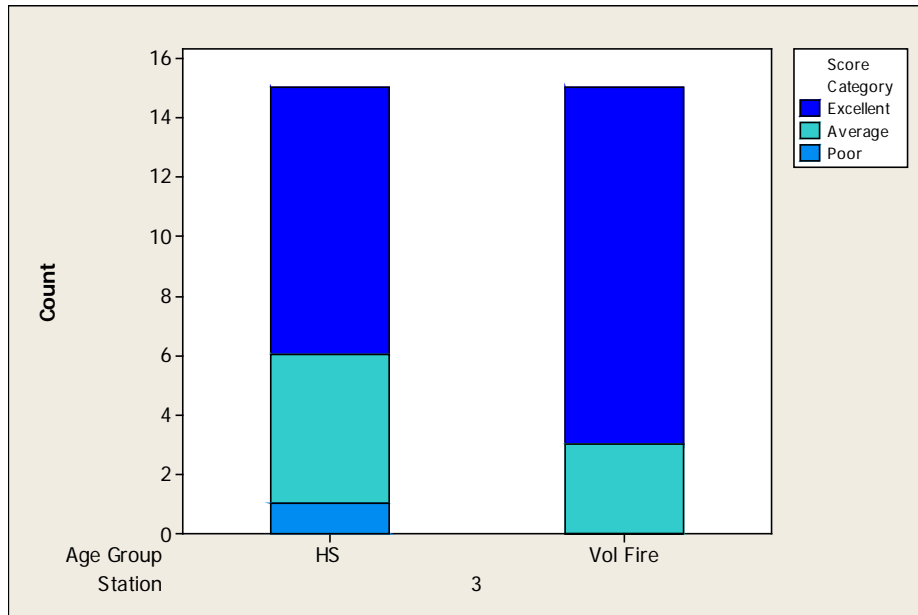


Figure 6. Comparison of the age groups and score categories in Station 3.

**Result #3: There was a significant difference between the two age groups in Station 2 and Station 4.**

Station 2 worked with percentages and discounting prices. The high school students struggled the most with this station. On average, the high school students scored an average 5.4 points while the firefighters had an average of 9.067points. After completing a one-way analysis of variance between the age groups, the F-value was 36.89 and the p-value was 0.000. These statistics support the hypothesis that the 12th grade students would have more difficulty with percentages and mental computation.

Working with percentages was relatively easy for the firefighters as evidenced by Figure 7. The students, though, had more difficulty with it. While 11 firefighters received an “Excellent”, no high school students received a score high enough. Eight high school students, however, earned a “Poor” score.

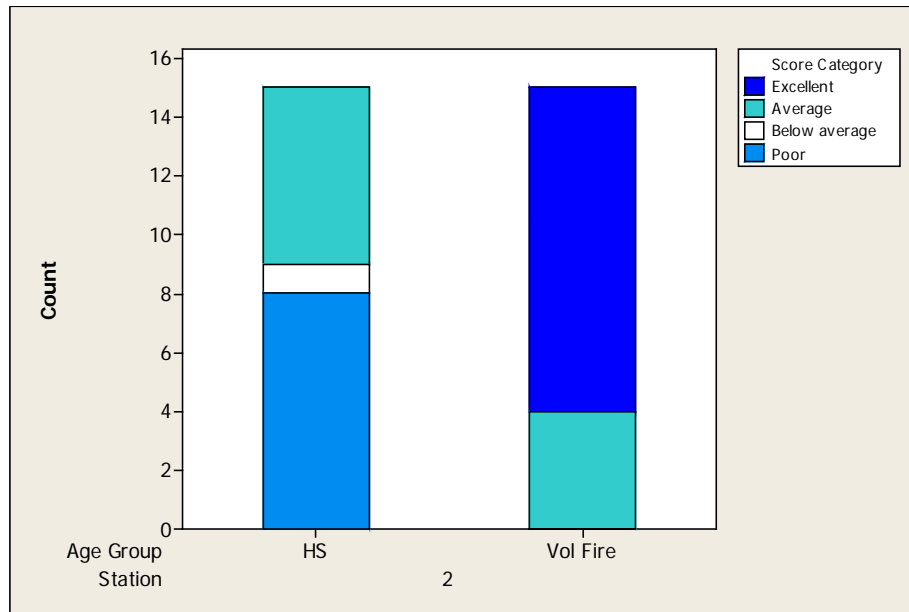


Figure 7. Comparison of age groups and score categories for Station 2.

The two samples below in Figure 8 show just how much the students struggled with this station. A 90% discount should have reduced the price of a \$25 product by more than a dollar and a 15% discount should have reduced a \$43 product to \$36.55, not \$8. The students explain how they determined their answers in the follow up surveys. At least one student wrote that they had guessed during this station.

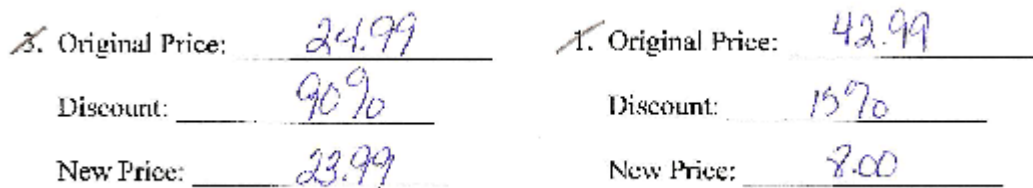
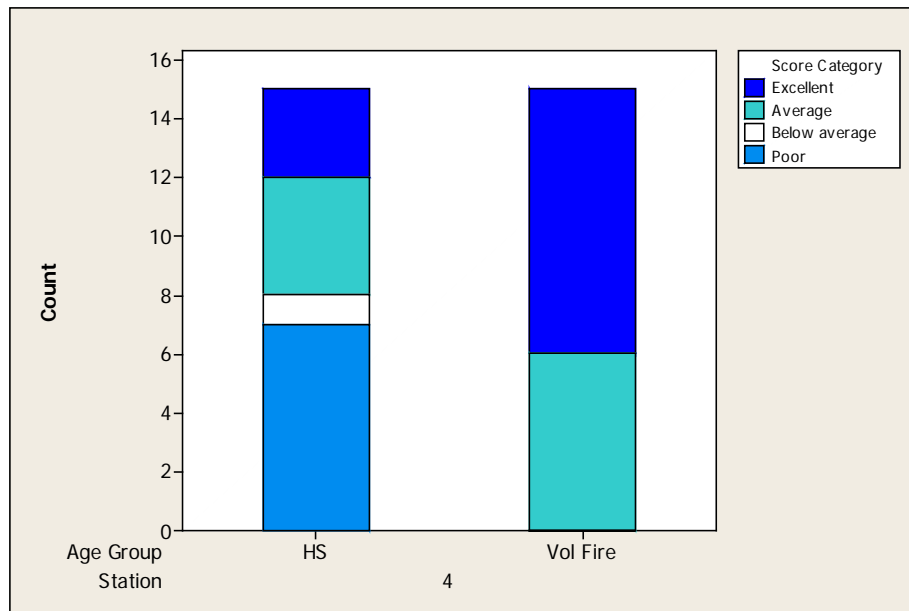


Figure 8. Participant samples.

Station 4 was the second hardest station for the high school students to complete. This station tested participants’ skill with percentages and tips. The firefighters had an average score of 9.0 points, but the high school students only scored an average of 6.267 points. An analysis of variance (ANOVA) test computed an F-value of 16.19 and a p-value of 0.001. These statistics support the hypothesis that high school students had more difficulty performing mental mathematics using percentages without technology.

While the majority of the firefighters had no difficulty in completing this station, the same is not true for the high school students. Figure 9, below, illustrates that sixty percent of the firefighters received a score that was “Excellent”, but only 20% of the high school students earned the same score. Forty-seven percent of the students received a score that was “Poor”.



**Figure 9. Comparison of age groups and score categories for Station 4.**

The student sample seen in Figure 10 shows all three answers for station 4. The student clearly struggled with this station. The only one they were close to getting correct was the third question. All of the participants were able to double the tax in order to figure out the tip. However, many of the students were unsure what percentage of a tip that was. The participants

were informed that the tax in Erie County is 8.75% and even given that information they did not know how to figure out the percentage of the tip.

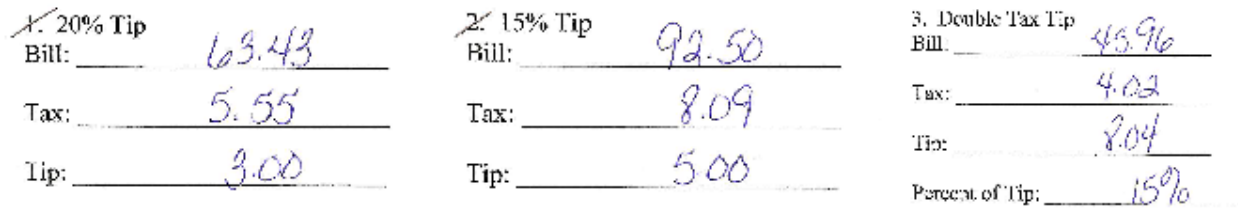


Figure 10. Student sample.

**Result #4: The older participants used more effective methods concerning percentages than the high school students.**

The firefighters were able to clearly state and explain the methods they used to complete stations 2 and 4. Many of the older participants used similar methods and were able to answer the problems correctly. Figures 11 and 12, below, show the most common methods used by the firefighters to solve mathematical problems involving discount percentages.

*Sometimes calculated the amount off + subtracted  
 other times calculated the amount to pay  
 (for example 90% - only pay 10% of price)*

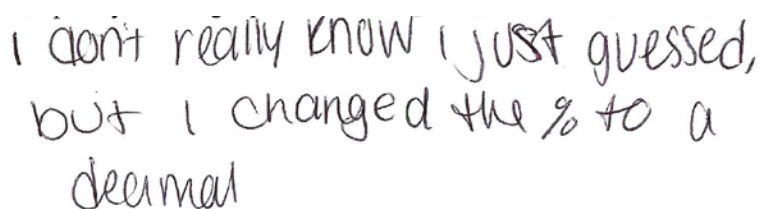
Figure 11. Firefighter survey sample.

*Figuring multiple of 10% and subtracting*

Figure 12. Firefighter survey sample.

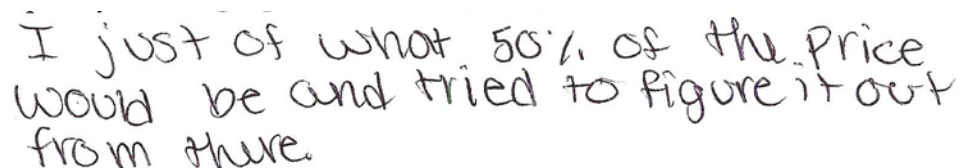
Both of the methods seen in the figures above are effective techniques to use when attempting to solve a percentage problem. Using these methods the firefighters were able to receive high scores in station 2.

The high school students struggled the most with station 2 and after examining their surveys it is clear that many of the students do not comprehend how to solve mathematical problems that involve percentages. In Figures 13 and 14, below, these students explained the approaches they used in order to complete station 2. However, neither method was effective and the students received 3 and 4 points for the station. While the method written in Figure 14 will be effective for some problems, overall it will be an unsuccessful technique for most percentage problems.



I don't really know I just guessed,  
but I changed the % to a  
decimal

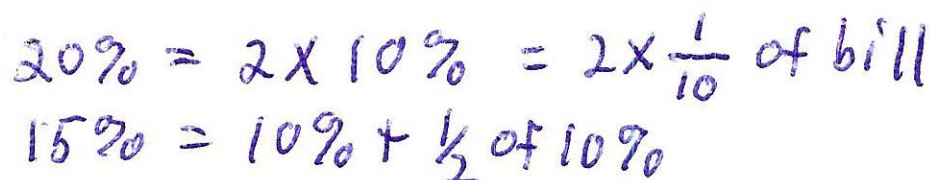
*Figure 13. Student survey answer.*



I just of what 50% of the price  
would be and tried to figure it out  
from there.

*Figure 14. Student survey answer.*

For station 4, the firefighters used either the same or similar methods to the ones they used to complete station 2. Figure 15, below, illustrates one of the firefighter's method in order to solve the mathematical problems. The technique used is simple and by using it the firefighter earned a score of 10 points.



$20\% = 2 \times 10\% = 2 \times \frac{1}{10}$  of bill  
 $15\% = 10\% + \frac{1}{2}$  of  $10\%$

*Figure 15. Firefighter survey answer.*

The high school students also struggled with station 4. Figures 16 and 17 show the answers and survey answer for station 4 from one student. As evidenced by Figure 17 this student was unable to conceive of a method that would have helped them solve the problems. For a bill of \$63.43 the 20% tip should be around \$12.80 and a bill of \$45.96 should have a 15% tip of about \$6.90. Instead, the student guessed at what the answers were and received a score of 4 points.

Tips		
1. 20% Tip Bill: <u>63.43</u>	2. 15% Tip Bill: <u>45.96</u>	3. Double Tax Tip Bill: <u>92.50</u>
Tax: _____	Tax: _____	Tax: <u>8.09</u>
Tip: <u>5.60</u>	Tip: <u>3.25</u>	Tip: <u>16.18</u>
		Percent of Tip: <u>20%</u> <small>with</small>

**Figure 16. Student answer for station 4.**

just kind of ~~guess~~ guessed something that seemed to make sense.

**Figure 17. Student survey answer for station 4.**

Figure 18, below, is another student explanation for how they completed station 4. The student’s answer for the first problem was close to the accepted range of answers, the second problem was incorrect, and the third problem was correct. After reading their survey answer for station 4, I was left wondering if the method they used actually worked for the first problem or if it was a correct guess.

Divide by % out of 100% then subtract from given amount.

**Figure 18. Student survey answer.**

Overall, most of the participants were able to successfully use mental computation to complete real world mathematical problems. The volunteers were able to easily use mental computation in order to solve problems involving simple addition and subtraction. However, problems relating to percentages were more difficult for the younger participants to solve.

### *Analysis of the Survey*

After participants completed all of the stations they were asked to complete a survey. The survey asked 5 questions which are shown in Figure 19. These questions were asked in order to determine the different methods participants used in order to solve the mathematical problems using mental computation.

1. Explain your thought process for completing Station 1.
2. Explain your thought process for completing Station 2.
3. Explain your thought process for completing Station 3.
4. Explain your thought process for completing Station 4.
5. Please list the stations by difficulty from easiest to hardest and explain.

**Figure 19. Survey questions.**

As evidenced by Figure 20, station 3 was considered to be the easiest station by 87% of the participants. All of the firefighters and 11 of the students thought station 3 was the easiest. Forty percent of the participants chose station 2 as the most difficult station. However, more of the firefighters thought station 1 was difficult, while the students considered station 2 the hardest. Many of the firefighters found station 1 to be the most difficult because it required keeping multiple numbers in your head while following specific directions. The explanation that was most puzzling from some students was that the reason they struggled with stations 2 and 4 was because they work better with decimals.



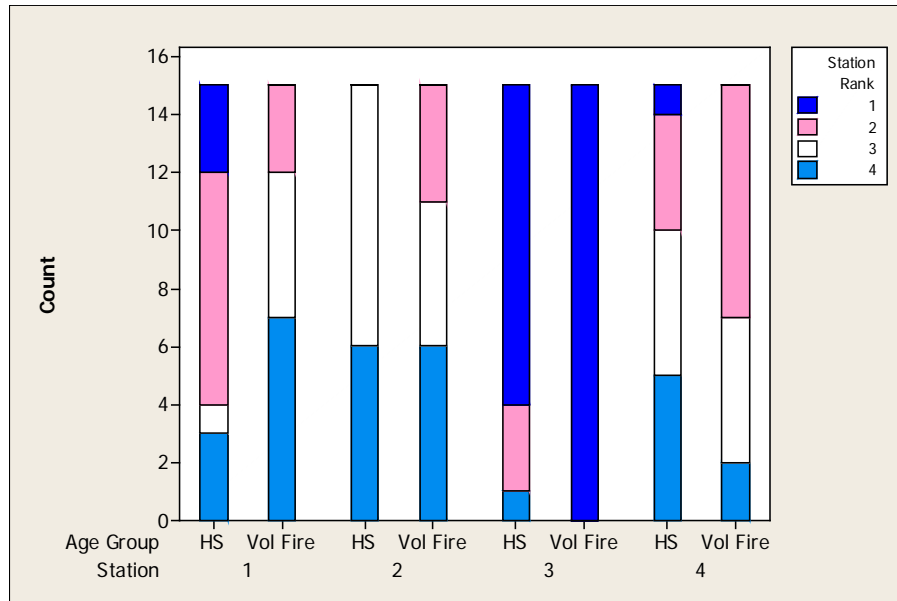


Figure 20. Station rankings for both groups.

The surveys were used to determine the thought processes of the participants. Figure 21, below, is one student’s explanation of how they worked through station 2. It would also help to explain why they scored so poorly on it. The student received 3 points for station 2 and 4 points for station 4. While it is not a terrible strategy, it will only work in certain cases. For both percentage stations the student used this method in order to complete the problems. For the 15% and 20% tip problems this student gave an incorrect answer. They were able to give the correct answer for the double tax tip however, when asked what the percent of a double the tax tip would leave they answer 10%.

2. Explain your thought process for completing Station 2. (Discount)  
 I found 50% then based the percentage off of that.

Figure 21. Student survey answer.

Another student used the method seen in Figure 22 and received 8 points for station 2 and 10 points for station 4. This method proved to be very effective for this student. They had two

incorrect answers in station 2 but correctly answered all of the problems in station 4. In station 2 the student stated that 30% of \$24.99 was \$16.50 but the correct answer is \$17.50. The student also answered that 90% of \$49.99 was \$10.00 when it is actually \$5.00. Overall, this student was one of the highest scoring for the high school students.

2. Explain your thought process for completing Station 2. (Discount)

Breaking down into 10% then multiply to get whole discount

**Figure 22. Student survey answer.**

Figure 23, below, illustrates one the firefighters answer to survey question 2. He clearly demonstrates how he solved each problem for station 2. Each method was simple and straightforward and by using these methods he received 10 points for this station. He broke down each percentage into parts that were easy to solve alone and then used addition to find the new price.

Rounded all q¢ amounts up to \$1.00  
 did percentages in my head: 90% discount price is 10%  
 60% " =  $\frac{1}{2} + \frac{1}{10}$  off  
 15% =  $\frac{1}{10} + (\frac{1}{2} \times \frac{1}{10})$  off  
 30% =  $3 \times 10\%$  off      75% = price is  $\frac{1}{2} + \frac{1}{4}$  off

**Figure 23. Firefighter survey answer.**

It was hypothesized that station 1 would be relatively easy for the participants, as it involved simple addition and mental computation. In general this was true. Very few participants struggled while completing this station and some of that difficulty stemmed from having to remember a long list of numbers. Many of the participants wrote they had a hard time remembering all of the prices of the products they were attempting to “buy”. Only a few participants had trouble with the addition itself. By observing all of the participants while they

were completing this station I noticed that many of them used the same methods to solve the problems. Some volunteers would pick higher priced items so that they would not have to add as many numbers together. Others would pick all of the lower priced items with one or two higher priced items. One of the problems told the participants that they had to spend between \$9 and \$10 but they were to buy only one product but multiple items. As one participant was contemplating the products he told me that he was having trouble finding a product because 10 divided by 3 was 3.33 and there were no products with that price. There were many products that any number of multiples of their prices would fall between \$9 and \$10 so I do not know why he fixated on \$3.33. Both of the age groups were able to complete station 1 with relative ease.

It was hypothesized that station 2 would be difficult because it involved percentages. Overall this was true. While station 2 proved to be easy for the firefighters to complete, the high school students struggled immensely with it. The firefighters used methods that they understood and knew would help them answer correctly. The high school students however, either did not understand the method they were using or simply guessed at the answer. Some of the high school students used methods that were effective and were able to explain those methods. Other students gave explanations as to how they solved the problem that were confusing or they stated that they guessed. After talking with a few of the students about percentage problems one student informed me that he understands decimals more than he understands percentages. This was one of the stations where there was a division between the two age groups.

Station 3 was hypothesized to be the most difficult for the high school students. It was hypothesized that the firefighters would be able to complete this station without any difficulty. Both of the age groups were able to solve the mathematical problems in this station quite easily. Station 3 had the highest average score for both the firefighters and the students. Only a few

students struggled in this station. For this station the participants were given manipulatives to use if they needed them. The participants were also able to clearly explain their thought processes for the station.

It was hypothesized that station 4 that some of the participants would struggle but that overall it would not be difficult. This was a station that the firefighters were able to perform quite well at but the high school students were unable to. While the high school students were more successful at this station than at station 2, the scores were still quite low. Many of the students stated they just guessed at what they thought sounded like a good 15% or 20% tip. After reviewing some of their answers I would not want to be their waitress. One student left a \$5.00 tip on a \$92.00 bill and a \$3.00 tip on a \$63.00 bill. The firefighters were more adept at figuring out the correct amounts and at explaining what methods they used. Overall, percentages were difficult for students solve.

After completing this study I believe that there should be more class time devoted to mental computation and percentages. People should not solely rely on technology to do the work for them. This study has shown that people of all ages are capable of using mental computation in order to solve everyday mathematical problems.

### **IMPLICATIONS FOR TEACHING**

The hypothesis for this study was that 12th grade students would struggle while doing everyday mathematics problems without the use of technology. It was also hypothesized that adult participants would be able to complete the same tasks without difficulty. While the high school students definitely struggled with some tasks more than others, they were not completely hopeless without the use of technology. After grading and analyzing the results from the stations

I have determined a few factors that I would incorporate in my classroom to ensure that students will use mental mathematics instead of technology for some problems.

- *Educators should continue to use mental mathematics in the classroom.*

Instead of letting students rely on the calculator for basic mathematics, educators should at least attempt to get their students thinking. Students should endeavor to work through simple addition, subtraction, multiplication, and division first before they turn to the calculator. The more students practice and use mental mathematics the better they will become at it.

This study has illustrated that people are capable of using mental mathematics and they should be encouraged to do so. This attitude needs to start in the classroom though. If the teacher allows students to constantly check simple mathematical problems on a calculator instead of trying to use mental computation first, the students will begin to rely on the technology instead of themselves. This could become a problem in the future. I had a professor in college who would not let us take a test with our graphing calculators because he wanted to ensure there was no cheating on his exams.

After examining this study it is obvious that while many of the students and adults were able to use mental computation for addition and subtraction, the students were incapable of using mental computation for problems involving percentages. As evidenced by the adults there were a few methods that could have been used to complete stations 2 and 4. However, the many of the students did not know how to solve percentage problems.

Calculators do have a place in the math classroom. However, that place should not be because a student does not want to think through a basic mathematics problem. I once sat in a class where the teacher told a student to use their calculator to figure out what 12 divided by 3 was. For a problem this simple the first choice of the both the teacher and the student should have been mental computation and not technology.

- ***Educators should teach students without technology first.***

Mathematics lessons should be taught using older methods first before students are shown the shortcuts with technology. Every student, no matter what grade level, should have some background knowledge of what work the calculator is doing. My elementary school did not allow the use of calculators for mathematics. We were not allowed to use one until we started middle school and even then there were restrictions on when we could use the calculator. My teachers always ensured we would be able to work through a problem on our own before they would show us what the calculator could do. They wanted to make certain that we understood the lesson and were capable of performing the tasks ourselves. Once we understood the lesson, the teacher would let us use the shortcut.

Most of the participants in the study were able to compute basic mathematics using mental computation and estimation but there were a few who struggled with it. If teachers expect students to perform basic mathematics in their head instead of using the calculator, this skill will increase. If students have to pay attention to what they are solving as opposed to typing it into a calculator they will start to recognize patterns and even mistakes.

Percentages is one subject that needs to be taught without technology first. I believe the reason some of the students did so poorly with percentages was because they believe they need a calculator in order to solve them. There are different methods that can be used to solve percentages but only a select few high school students were aware of them and were able to successfully use them.

Technology in the classroom is important and there are so many concepts that it can help us visualize, but students need to recognize when technology use is a crutch instead of a tool. Every classroom should have technology in it and it should be used but there should be some limits as to what it is used for. A calculator should not be used for basic mathematics. The human brain is like any other muscle in the body, it needs to be exercised and by performing mental mathematics instead of letting technology do all the work for us, will help keep it sharp.

- ***Educators need to spend more time teaching percentages and they need to find different methods for teaching them.***

Percentages should be treated like any other mathematical concept. The more students are exposed to percentages, the easier percentages will become. Clearly more time needs to be spent on teaching students how to solve problems with percentages without using technology.

Many teachers do not allow their students to use the calculator for simple addition, subtraction, multiplication, and division. I believe that the same restriction should be placed on percentages. The more students are required to work through these types of problems, the easier they will become.

This study had shown that there is a lack of understanding about working with percentages. Percentages are seen in multiple settings in the real world and there needs to be more emphasis placed on learning them in our classrooms. The purpose of school should be to prepare students for the world and the skills they will need to navigate it. While higher level concepts should be taught so that students have a well rounded education, the basic skills they will need for everyday life should not be glossed over.

Math should not be a one size fits all subject. There are so many different ways to solve all types of mathematical problems. The same is true for percentage problems. When I was in school we learned one way to solve percentage problems. This needs to change. Many students do not understand how to solve these problems with that way and they should be given a chance to learn a different method.

When percentages were first introduced we learned one method for solving them. It involved using an equation of  $\text{Part/Whole} = \text{Percent}/100$ . Depending on what the problem was asking you might then have to go one step further and subtract the answer from the “Whole”. I was taught another way to solve percentage problems but when I tried to explain it to my teacher he stated that it was too difficult for the other students to understand. For percents that involved discounts I was taught to multiply the original number by the percent that you’re going to pay. So if an item is 60% off, I would multiply by 40%. Using this method eliminates the subtraction step. Other students would break the percentage into multiples of 10% percent and subtract multiple times. Our teacher never discouraged us from learning and using other methods but he only taught us the one method.



Students should also be shown ways to use fractions and decimals as well. There are times when turning 75% into  $\frac{3}{4}$  and working with the fraction is easier. Other times working with the decimal will prove better. Students need to recognize that there are multiple ways of solving mathematical problems. However, in order for that to happen educators need to show students more than one way.

I believe that if other methods for solving problems involving percentages students would see that percentages are not that difficult. If a student could find a method that they understood they may be more willing to solve these problems using mental computation instead of a calculator.

While the students had explanations for the techniques they used for this study, most of them still did not succeed in getting the answer correct. Every other subject in mathematics is taught in multiple ways to ensure that every student is able to find a way to accomplish their goals. Some of the students were on the right track and I believe with further instruction they would be more comfortable working with percentages.

### ***Suggestions for Future Research***

While this research did support the hypothesis to an extent, further research might still be conducted in order to determine how prevalent technology is in our everyday lives. A larger group of subjects with more age differences may result in further support of the hypothesis. Instead of comparing just adults to 12th grade students, it would be interesting to see how 9th grade, 10th grade, 11th grade, and 12th grade students compare to adults whose ages are 19 and up. A study of all of these grades and generations could determine if technology use is more prevalent in the younger grades and generation as opposed to the older grades and generation.

***Concluding Remarks***

The goal of this study was to determine if people are too dependent on technology in today's world. Examining the results of this study, it appears that while many people prefer to use technology, they are still capable of solving real world mathematics with mental mathematics most of the time. We as a society need to continue to use our brains for simple tasks and not turn to technology to do everything for us.

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## Appendices

### Appendix A

Station 1. Participants will be shown a number of products all with different prices. They will be told to use mental math in order to reach a given amount of money without going over it. They will be told that they have to get as close as possible to this amount and that they can't short it by more than a certain amount of money. Participants will be graded based on how closely they were able to get to the given amount of money. I believe that participants may have less trouble with this station but it will depend on how they estimate the prices of the products.

Station 2. Participants will be told that for this station they will be estimating discounts of different products. They will not be given a calculator. They must figure these numbers out using mental math. They will be given 5 products and each product will be discounted by a percent. Participants will be graded based on how closely they are to the correct answer. Due to this being about estimation I understand they will not be a one correct answer so I will handle that accordingly. I believe that participants will struggle with this station as they are working with percents.

Station 3. Participants will be given a cash box with money and no calculator. They will then be given a total amount and told how much money someone gave them. Participants will be expected to use some method in order to give that person their correct change back. Participants will be graded based on how well and how quickly they were able to produce the proper amount of change. They will have to do this 5 times.

I believe that participants will struggle immensely with this skill and will either be unable to produce the proper amount of change or will be unable to perform it quickly.

Station 4. Participants will be given a check and told to figure out the tip for the waiter. They will have to use some sort of mental math and not allowed to use their phones or a calculator for this station. Participants will complete this station 3 times. The first time they will have to figure out a tip of 20%, the second time a tip of 15% percent, and the last time they will double the tax. Also for the third time participants will have to tell me what they believe the percent of the last tip is. I believe that participants will perform this station relatively well as this is a skill more people use everyday.

**Appendix B**

The participants will be assessed based on this table. Their answers will be looked at to see how close they came to the correct answer and what method they used to complete the station. I also want to record how much time it takes participants to complete the different stations. I will take the information from this table and give the participants a score based on the rubric below. After the participants have completed each station I will give them a short questionnaire asking them to explain their thought processes and how they arrived at their answers.

Rubric

	2 Participant gave up and was unable to complete station.	4 Participant attempted to complete station. Had incorrect answers.	6 Participant completed station. Had some correct answers.	8 Participant completed station. Had mostly correct answers.	10 Participant completed station. All answers are correct.
Change Back					
Discount					
Shopping					
Tip					

**Appendix C**

## Shopping

1. Buy all different products to spend between \$18 and \$20.
2. Buy all different products to spend between \$23 and \$25. There needs to be two products that have multiples.
3. Only buy one product to spend between \$9 and \$10.
4. Only buy three products to spend between \$13 and \$15. (Multiples of any of the three products are allowed.)
5. Buy 10 products to spend between \$33 and \$35 dollars. But 3 items must be the same and a different 2 items must be the same. (You should have a total of 13 items but 10 different products.)

**Appendix D**

## Discount

1. Original Price: \_\_\_\_\_

Discount: \_\_\_\_\_

New Price: \_\_\_\_\_

2. Original Price: \_\_\_\_\_

Discount: \_\_\_\_\_

New Price: \_\_\_\_\_

3. Original Price: \_\_\_\_\_

Discount: \_\_\_\_\_

New Price: \_\_\_\_\_

4. Original Price: \_\_\_\_\_

Discount: \_\_\_\_\_

New Price: \_\_\_\_\_

5. Original Price: \_\_\_\_\_

Discount: \_\_\_\_\_

New Price: \_\_\_\_\_



**Appendix E**

## Counting Back Change

1. Bill: \_\_\_\_\_

Amount Given: \_\_\_\_\_

Change: \_\_\_\_\_

2. Bill: \_\_\_\_\_

Amount Given: \_\_\_\_\_

Change: \_\_\_\_\_

3. Bill: \_\_\_\_\_

Amount Given: \_\_\_\_\_

Change: \_\_\_\_\_

4. Bill: \_\_\_\_\_

Amount Given: \_\_\_\_\_

Change: \_\_\_\_\_

5. Bill: \_\_\_\_\_

Amount Given: \_\_\_\_\_

Change: \_\_\_\_\_

**Appendix F**

Tips

1. 20% Tip

Bill: \_\_\_\_\_

Tax: \_\_\_\_\_

Tip: \_\_\_\_\_

2. 15% Tip

Bill: \_\_\_\_\_

Tax: \_\_\_\_\_

Tip: \_\_\_\_\_

3. Double Tax Tip

Bill: \_\_\_\_\_

Tax: \_\_\_\_\_

Tip: \_\_\_\_\_

Percent of Tip: \_\_\_\_\_

**Appendix G**

1. Explain your thought process for completing Station 1. (Shopping)
2. Explain your thought process for completing Station 2. (Discount)
3. Explain your thought process for completing Station 3. (Making change)
4. Explain your thought process for completing Station 4. (Tip)
5. Please list the stations by difficulty from easiest to hardest and explain your reasoning.

**Appendix H**

I would appreciate your collaboration in this very important project. Please sign below to indicate your agreement to participate in this study. You may retain a copy of this letter for your own files. Thank you for giving this request your full consideration.

**STUDENT CONSENT FORM**

SUNY Fredonia

**Voluntary Consent:** I have read this memo. My signature below indicates that I freely agree to participate in this study. If I withdraw from the study, I understand there will be no penalty assessed to me. I understand that my confidentiality will be maintained. I understand that if I have any questions about the study, I may telephone Karla Mead at (716)648-6880, or reach her by e-mail at: K.mead@fredonia.edu

Please return this consent form by March 31, 2014. Thank you for your cooperation.

Student Name (please print)

---

Student Signature

---

Date: \_\_\_\_\_

**Appendix I**

I would appreciate your collaboration in this very important project. Please sign below to indicate your agreement to participate in this study. You may retain a copy of this letter for your own files. Thank you for giving this request your full consideration.

**CONSENT FORM**

SUNY Fredonia

**Voluntary Consent:** I have read this memo. My signature below indicates that I freely agree to participate in this study. If I withdraw from the study, I understand there will be no penalty assessed to me. I understand that my confidentiality will be maintained. I understand that if I have any questions about the study, I may telephone Karla Mead at (716)648-6880, or reach her by e-mail at: K.mead@fredonia.edu

Please return this consent form by March 31, 2014. Thank you for your cooperation.

Name (please print)

---

Signature

---

Date: \_\_\_\_\_

**Appendix J**

I would appreciate your collaboration in this very important project. Please sign below to indicate your agreement to participate in this study. You may retain a copy of this letter for your own files. Thank you for giving this request your full consideration.

**PARENTAL CONSENT FORM**  
SUNY Fredonia

**Voluntary Consent:** I have read this memo. My signature below indicates that I freely agree to allow my son/daughter to participate in this study. If I withdraw my son/daughter from the study, I understand there will be no penalty to him/her. I understand that my child's confidentiality will be maintained. I understand that if I have any questions about the study, I may telephone Karla Mead at (716)648-6880, or reach her by e-mail at: K.mead@fredonia.edu

Please return this consent form by March 31, 2014. Thank you for your cooperation.

Parent/Guardian Name (please print):

\_\_\_\_\_

Parent/Guardian Signature:

\_\_\_\_\_

Date: \_\_\_\_\_

Parent/Guardian E-mail: \_\_\_\_\_