Influence of Time-of-Day on
Student Performance on Mathematical Algorithms

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Submitted in Partial Fulfillment of the Requirements for the Degree

Master of Science in Education: Curriculum and Instruction

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San Rafael, CA

December 2005

Acknowledgements

The process of undertaking this project could not have been accomplished without the guidance and continual support of my professors at Dominican University of California. Susan Roddy, Dr. Linda Sartor, and Dr. Madalienne Peters were my touchstones throughout this process—they encouraged and compelled me to discover what was right for my project. I would also like to acknowledge my classmates who were always there for support, as well as excellent peer editors throughout this process.

This project was only realized because of the support of the staff, students, and parents at the site of the research. Especially, I would like to acknowledge the principal who not only helped with the logistics of conducting this research, but also was always available to listen and help problem solve.

Finally, I would like to acknowledge my friends and family who demonstrated a great deal of understanding during this process. Thank you especially to Dr. Adam Bell who guided me through some of the technical aspects of this project, as well as provided emotional support. Their interest and thoughtfulness supported me throughout this process.

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Abstract

In the current school climate of standards-based curriculum and the emphasis on measuring student achievement by state-mandated standardized testing, teachers have to carefully allocate instructional time with emphasis on reading and mathematics. The assumption often is that these subjects need to be taught in the morning when students are more alert. The purpose of this study was to examine the influence of time-of-day on elementary students' accuracy in computing mathematical algorithms. This study used an explanatory mixed methods design to collect data on addition quizzes at three different times of the day over a period of three weeks. This study also used a student questionnaire so that students could reflect and explain when they felt they concentrated the best on the quizzes. The sample population used in this study includes eighteen third grade students from a suburban elementary school.

An analysis of variance was performed on the data. Findings were not significant for the time-of-day on student performance on the quizzes. An examination of the mean scores showed a trend toward higher scores in the morning, followed by the mid-morning, then the afternoon. The responses to the student questionnaires revealed trends in why they felt they concentrated best at different times, but the responses did not correspond to any particular time-of-day. The results of this study add further information on the effects time-of-day has on student performance in mathematics.

Introduction

When President Bush signed No Child Left Behind (NCLB) into law in January 2002, he intended to introduce a program to help every child succeed academically. NCLB test results are used to evaluate children, teachers and schools. In California, student scores on the Standardized Testing and Reporting (STAR) test given in the spring are used to determine if *adequate yearly progress* (AYP) has been made. AYP is used each year to determine that achievement of each school district and school. Unfortunately, these new tests of accountability set “fanciful AYP expectations regarding students’ performances on those tests” (Popham, 2003, p. 3). These are the new rules with which teachers and administrators need to comply. The stakes are high; schools that do not make their pre-determined AYP “may suffer sanctions that include loss of federal funding, termination of staff, and dissolving the school district” (Rose, 2004, p. 121).

A standardized curriculum creates the expectation at the school or district level that all students will receive instruction in the same curricular areas in the same grade, regardless of teacher or school. Marzano indicates, “without a standardized curriculum, public education has little chance of significant improvement” (2002, p. 6). However, as it presently stands, the standards that have been produced are “bloated and poorly written standards that almost no one can realistically teach to or ever hope to adequately assess” (Schmoker & Marzano, 1999, p. 19). Thus each school year, educators are under pressure to cover the standards before the NCLB assessments in the spring. Teachers must do what they can to define and teach the essential standards in the limited time that they have with their students each school year.

The advent of NCLB and the adoption of a standards-based curriculum have led some educators to declare that there is simply not enough time to address all of the standards, and to wonder if lengthening the school day or school year is a solution. In a time California is in a budget crisis, the cost of adding more school days is not a viable option, nor is it necessarily a good solution. Some say that additional classroom time does not necessarily lead to additional academic learning time (WestEd, 2001). Perhaps it is not the quantity of time, but the quality of time that matters. By using class time effectively, perhaps teachers can begin to increase student academic learning time and, therefore, increase student learning and achievement.

Caine and Caine (1998) have suggested that in order to change the way educators teach, teachers need to become introspective. That is, we must examine educational beliefs and be willing to challenge them. Time of day when curricular subjects are taught is just one of many things components that need research. Teacher lunchroom conversation often seems to include laments about teaching anything academic in the afternoon.

Traditionally, in self-contained elementary classrooms, core subjects such as reading and mathematics have been taught in the morning, when students are perceived to be alert. However, teaching these core subjects only in the morning session does not provide enough instructional or practice time to effectively teach the essential standards as prescribed by law. Indeed, more and more teachers are finding it necessary to extend the learning time of core subjects into the afternoon hours. The impetus for conducting this research project is a desire to discover how best to use time-of-day influences in an academic setting.

Theoretical rationale

In order to understand how the brain's memory may function differently at different times of the day, it is important to understand how the brain processes and stores data. One way the brain's different memory types are classified is by short-term memory and long-term memory. Short-term memory is broken down into immediate memory and working memory. Immediate memory will hold data for a short amount of time and then drop it if the brain registers that it is unimportant. Working memory is the conscious memory. Pre-adolescents are able to hold an average of five items in their working memory for a finite amount of time before fatigue sets in (Sousa, 2001, p. 45). In order for the brain to continue processing this information in the working memory, the information must be dealt with in a new or different way. Information taken in during the day will be encoded in the brain during deep sleep. If information is not put into long-term storage, it will be lost within the next 24 hours. Therefore, testing to see if information is in long-term storage is effective after 24 hours or more have passed (Sousa, 2001, pp. 49-50).

“Learning is the process by which we acquire new knowledge and skills. Memory is the process by which we retain knowledge and skills for the future” (Sousa, 2001, p.78). Sometimes teachers focus on the learning aspect of teaching, but without retention the learning is lost. A goal of effective teaching is for students to retain the things they are learning. Getting a student to learn more is not as simple as teaching more. The brain needs time to process the new information. New information is processed and reprocessed through rehearsal. Rehearsal is necessary to transfer information from working memory into long-term storage (Sousa, 2001, pp. 85-86).

Students learn best what information they hear during the first part of a lesson and second best what they hear during the last part of a lesson. The information in the middle is often times lost because the brain is busy processing what came first (Jensen, 2000, pp. 224-225; Sousa, 2001, pp. 88-89). This *down-time*, as Sousa calls it, is the time when students should be working independently with the new information that was presented. This allows the brain a break from receiving new input and allows for processing which will lead to retention.

People give their focus and attention in varying amounts depending on how they perceive a stimulus. Sousa (2001) identified a hierarchy that can reveal why students sometimes have difficulty paying attention. Stimulus affecting survival gets immediate and undivided attention. Next in the hierarchy is stimulus that generates an emotional response. Lastly, stimulus that is novel and different will also gain attention (Sousa, 2001, p.43). From this, it is easy to see that students must feel safe and secure in the classroom before they can attend to learning and also that new learning that is made novel will get more attention than something mundane. Moreover, unlike memory functions, teachers may have some control over student attention.

Age is also a significant factor when it comes to attention and time-of-day influences. Sousa (2001, p. 102) points out, that ability to focus in pre-adolescents and post-adolescents rises in the morning and then remains steady until about mid-day when there is a significant drop. Focus then increases again, but not to as high a degree as in the morning. Focus then slowly tapers off throughout the remainder of the day until sleep occurs. The dip for pre-adolescents and post-adolescents is from 12:00 p.m. to 2:00 p.m. It is significant to note that this pattern for level of focus shifts for adolescents. Their dip in focus occurs approximately one hour later and lasts from about 1:00 p.m. to 4:00 p.m. So what may be true in studies involving adolescents may not hold true for elementary-aged students. However, according to Sousa (2001, p.102), the levels of focus throughout the day for pre-adolescents and adults are the same.

Background and need

Many years ago, researchers started investigating whether factory workers were able to perform their job accurately at different times of the day. Later, other researchers looked into how the body and brain function at different times of the day to see if there is any correlation as to why some tasks are performed better than others at certain times of the day. Brain researchers found that short-term memory is better in the morning and long-term memory is better in the afternoon. So, how does that relate to regular classroom practice? More specifically, applying this finding to classroom practice may help teachers teach and students learn more effectively.

Bringing brain research into the classroom has been a slow process. The limited practical research in this area helps answer some questions about time-of-day influences on attention, memory, and scholastic student achievement, but leaves other questions unanswered.

Zephaniah Davis (1987a) administered a yearlong study examining time-of-day influences on student achievement and it was found that students instructed in reading during the last period of the day had more gains than those instructed in reading during the first period of the day. In a similar study, Davis (1987b) found that the above result was not the same for math, which the overall yearly math achievement of the students was not determined by whether they had math instruction in the morning or the afternoon.

It seems that one study about mathematics and time-of-day influences is not sufficient and that more research along this line of inquiry could lead to more useful conclusions. The Davis (1987b) study examined different groups of eighth grade students who were instructed at different times of the day. This study contributes to this literature by examining a single group of third grade students to see if they perform differently in math at different times of the day.

A purpose for this study includes making it easier for teachers to implement the findings of brain research in classroom instruction. Teachers who apply brain research techniques to instruction may find that their students learn efficiently, thus providing more instructional time to master standards. In a broader context, the educational community might direct teacher attention to best practices gained through an examination of this study.

Research Purpose

The purpose of this study is to add to the research of the effects of time-of-day influences on student achievement by examining the differences in achievement of one class of third grade students in calculating three column addition problems at various times of the day. Addition with regrouping was used in this study to simulate the type of math practice students need in order to master a skill. The null hypothesis is that there is no statistical significance in student accuracy, based on time of day.

Assumptions

My assumption is that the rationale behind the way many teachers structure their academic learning time is not soundly based and needs to be rethought. Another assumption is that teacher perception of time of day impact on students generates the reality that instruction in the afternoon is worthless. I believe that by applying what is known about how the brain functions to the classroom, a better way to teach can be revealed.

Regarding the methodology of this study, I assume that the day of the week does not influence the time of the day for data collection. I also assume that the quizzes I designed provide a reasonable measurement of practice on a previously-learned skill, as opposed to testing their improvement in the skill of addition. The statistical trends in the data and may decide to collect additional data if it is warranted. Some of these assumptions are based on personal experience, and some are based on the research that has already been conducted in this area.

Review of the Literature

While conducting this literature review, the idea that people might have a learning style *preference* in relation to time-of-day appeared prominently in various articles in the literature. The theory is that if someone is taught during his or her preferred time-of-day, then he or she might perform better on the task at hand. Even though a person may have a preferred time-of-day for learning a particular subject, the span of times that various students would prefer might extend from early morning to late at night. This would make it impossible to implement in an elementary classroom— a lesson would always be presented at someone's non-preferred time-of-day for that particular subject. Because the aim of this review is to look for trends in time-of-day effects, time-of-day preferences are not examined.

This review analyzes empirical studies involving time-of-day influences on various aspects of student learning. Books published on how the brain functions and learns in relation to time-of-day are also examined. During the past decade, research about how the human brain functions has accumulated, but has not, for the most part, made its way into classroom practice. Caine (2000) points out:

> Taking neuroscience into the classroom is challenging because we cannot rely exclusively on brain research. People are too complex, individuals too unique, and contexts too unpredictable. Integrating brain research with other research and with an adequate model for instruction, however, can provide educators with a coherent foundation for excellent teaching. (p. 61)

This review gives a wider view of how to apply brain research to practice in the classroom in terms of time-of-day. First, the influence on time-of-day on memory is analyzed. Second, the influence of time-of-day on attention is examined. Next, time-of-day effects on long-term scholastic achievement are reviewed. Finally, implications and areas for future research are discussed.

Influence of Time-of-Day on Memory

Early studies (Laird, 1925: Blake, 1967; Baddeley, Hatter, Scott, and Snashell, 1970; Hockey, Davis, and Gray, 1972) suggested that performance of a variety of tasks fluctuates with time-of-day. Later, Blake related these fluctuations to changes in body temperature (1971). He found that our basal *arousal level* (essentially, a measure of mental alertness) and body temperature starts to increase upon waking and, with the exception of a dip after noon, continues to rise until about 8:00 p.m. According to Blake, when body temperature is high, so is arousal, and high arousal may interfere with short-term memory.

Because of the more recent definition of and findings about long-term memory (Sousa, 2001, pp. 49-50), some of the early studies attempting to look at long-term memory retrieval in relation to time-of day appear to be flawed. If information is in long-term memory only after at least 24 hours have passed (Sousa, 2001, p. 50), then some of these early studies that tested less than 24 hours following the introduction of the new information did not truly test for long-term memory retrieval. For one example, Laird (1925) tested recall only 40 minutes after the initial reading of the text.

Baddeley, Hatter, Scott, and Snashell (1970) found that long-term memory was slightly better in the afternoon as compared to the morning. They used a digit span test, but counted the sequences that were repeated within the test as a measure of long-term memory. It is unclear how much time elapsed between the first hearing of the sequence and the participants repeating of it, so perhaps not enough time elapsed to truly test long-term memory retrieval.

Finally, Hockey, Davis, and Gray (1972) tested for long-term memory retrieval of 40 undergraduate college-level females using a free recall task. Because the testing for long-term memory retrieval was performed after five hours had elapsed from the initial presentation, it is unclear if enough time had passed to truly test long-term memory retrieval. These early studies did, however, call attention to time-of-day effects and offered a starting point for researchers to follow.

In simple tests of short-term memory using immediate recall, Baddeley, Hatter, Scott, and Snashall (1970) found that short-term memory improved from early to mid-morning and then decreased steadily over the day. Additionally, Folkard, Monk, Bradbury and Rosenthall (1977) found that short-term memory recall was better in the morning than in the afternoon. The results of these studies are in line with the arousal theory (Blake, 1971): short-term memory decreases fairly steadily throughout the day due to increase in arousal.

Folkard (1980) and Oakhill (1988) found that information that has different degrees of significance within a text is remembered better at different times of the day. Upon re-examining the questionnaire used to test the children's recall in a previous study (Folkard, Monk, Bradbury and Rosenthall, 1977), Folkard (1980) found that the items that were immediately recalled by the students who heard the morning presentation had been classified by an independent team as less important (trivial). In contrast, students who heard the presentation in the afternoon recalled both important and unimportant information (Folkard, 1980). Similarly, Oakhill (1988) found that morning-tested students remembered more superficial aspects of the text whereas afternoon-tested students remembered more elaborate aspects of the text. Thus, even though short-term memory may be stronger in the morning, it may also favor remembering the less significant aspects of the text. These findings are significant if the purpose of education is to instill knowledge with deep connections, rather than to have students briefly memorize and subsequently forget trivial facts.

The time of testing for information learned does not appear to be as important as the time at which the learning was achieved (Folkard, Monk, Bradbury and Rosenthall, 1977; Peters, 1984). The Folkard et al. study-mentioned in the previous paragraph, compared students for recall at the same time-of-day as the initial presentation against recall at a different time-of-day as the initial presentation. Folkard et al. (1977) found that there was no significant difference in when the students were tested for information recalled. Peters (1984) examined the results from 131 students in first grade through fifth grade taking the Stanford Achievement Test in reading. She also found no significant difference in time-of-day effects on test-taking. Both these studies challenge the long-held assumption that testing students during the morning hours is necessary to give an accurate picture of what they know and support the null hypothesis.

Studies that truly looked at long-term memory retrieval— that is after at least 24 hours from the time of initial learning has passed— found that ability to retrieve information stored was stronger later in the day (Folkard, Monk, Bradbury and Rosenthall, 1977; Millar, Styles, & Wastell, 1995). Folkard et al. (1977) tested 12-year-old and 13-year-old students on delayed recall of a story heard seven days earlier using a multiple-choice questionnaire. He found that students who initially heard the story at 3:00 p.m. had better recall than those students who initially heard the story at 9:00 a.m. Millar, Styles and Wastell (1995) tested fifty-four adults (mean age 38.5 years) in a semantic classification on information that had originally been learned long before the testing. There were three testing periods: morning (9:15 a.m. or 10:00 a.m.), afternoon (2:15 p.m. or 3:00 p.m.) and evening (6:00 p.m. or 7:00 p.m.). Millar, Styles and Wastell found that long-term memory retrieval efficiency increased over the day. Although the participants of these studies vary in age and the tasks performed were diverse, these studies show that long-term memory retrieval may be stronger later in the day.

Memory is just one of many elements of learning that is influenced by body rhythms. Early studies showed differences in memory ability at different times of the day, but it is unclear whether some of these studies were testing for short-term or long-term memory. Generally, short-term memory has been found to be better in the morning and long-term memory has been found to be better later in the day.

Influence of Time-of-Day on Attention

In examining attention, Muyskens and Ysseldyke (1998) used observers to evaluate levels of attention in 122 second through fourth grade students (plus one fifth-grader) during one school day. The findings showed students were more engaged during the morning. Muyskens and Ysseldyke went further to examine the ecology of the classroom that is, the factors present or absent in the educational environment during the morning. They found that during the morning, academic activity was occurring, the instructor gave individual attention and students were performing active tasks. Their analysis of the classroom ecology during the afternoon showed that there was more whole group instruction and there were nonacademic activities occurring. This leads to the question of which came first, the inattentive behavior or a classroom ecology that supported inattentive behavior? What if the events that occurred in the morning that fostered attention occurred in the afternoon? Would students also be equally engaged in their studies as they were in the morning? Or is it true that level of focus does slowly drop off as suggested by Sousa? If the teacher plans to do academic work in the afternoon, would the students follow?

One study examines mathematics aptitude and levels of attention. Using a questionnaire to study self-assessed levels of attention in fifth and tenth grade students, Klein (2001) found that levels of attention were highest in the afternoon and lowest in the morning for fifth grade students no matter what their mathematical aptitude level (determined by their yearly mathematical aptitude tests). The reverse was found for 10th grade students. Even though math aptitude was correlated with perceived levels of attention, it is not clear which academic subjects were being studied during the different times of the day in this study. Perhaps the subject matter during their self-perceived periods of higher attention was more interesting to the students and that was the reason their attention level was higher no matter what the time of the day. Also, it appears that this questionnaire was given to the students to fill out for only one day. Because this is only a snapshot of one day in a student's life, it is difficult to draw far-reaching conclusions. Perhaps their higher levels in attention would shift to different times of the day, depending on the classroom ecology.

It is clear that attention is an important element in student learning (Sylwester & Cho, 1993). What remains unclear is if student attention is consistently affected by time-of-day influences. Because there seems to be many confounding influences (such as the classroom ecology factors identified by Muyskens and Ysseldyke in their 1998 study) when looking at attention, it is difficult to draw any clear conclusions about time-of-day effects on attention. Perhaps if teachers are better-prepared to make the learning interesting, then students would be focused and attentive to a level that would allow them to learn, no matter what the time-of-day.

Influence of Time-of-Day on Scholastic Achievement

Studies examining time-of-day influences on reading instruction offer further evidence that time-of-day of instruction also impacts student achievement. Reading achievement was found to have more gains for those instructed in the morning than in the afternoon (Davis, 1987a; Davis, 1987b; Barron, Henderson, Spurgeon, 1994). The Davis (1987a) study did not state the times of exact instruction, but referred to first or last period of the day, which is assumed to mean a morning time and an afternoon time. Two studies are significant because they were performed over longer periods of time: over one school year (Davis 1987a; Davis 1987b) and over two years (Barron, Henderson, & Spurgeon, 1994). The findings of all these studies may be a consequence of Folkard's result that long-term memory is stronger for those instructed in the afternoon. It is not clear from reading the Davis (1987a) report whether the test questions assess items that require short-term memory recall (such as questions after a short passage) or long-term memory recall (such as vocabulary, grammar and spelling questions) or, most likely, a combination of both. Because reading skills are developed over a substantial period of time, most skills used in reading rely on accessing long-term memory and therefore these findings speak in favor of having reading instruction in the afternoon rather than the morning.

As noted previously, only one study that specifically looked at time-of-day effects on mathematics instruction was found. Davis (1987b) examined time-of-day effects on instruction of 80 eighth grade students in the areas of mathematics. Students were assigned to either first-period mathematics (8:10 a.m.-9:10 a.m.) or last-period mathematics (1:00 p.m.-2:00 p.m.) for the school year. The same mathematics instructor taught both of these mathematics classes. The Comprehensive Test of Basic Skills was used as a pretest at the beginning of the year and again as a posttest nine months later. Davis found that “the fact that there was no apparent difference in achievement between morning and afternoon math groups is interesting and more difficult to interpret” (p. 79). Davis concludes that perhaps mathematics requires a balance of short-term memory and long-term memory and therefore did not strictly fall into a short-term memory task or a long-term memory task.

Summary

In the current school climate of high-stakes state-mandated testing and a substantial standardized curriculum, teachers need to allocate classroom time in language arts and mathematics instruction to the maximum benefit of student learning. Despite the long-held belief that students learn better in the morning, empirical studies and a mounting body of neurological research point to the possibility that this might not be strictly true.

The cognitive functions of memory and attention are key components of student learning. The research reviewed shows that tasks involving short-term memory may be better in the morning and tasks involving long-term memory may be better in the afternoon. The findings for attention were inconclusive, as attention seems a more nebulous entity to define and assess. The findings for long-term achievement in reading (Davis 1987a; Barron et al., 1994) however were clear: students taught during the afternoon showed greater achievement on year-end tests than those taught in the morning. Year-end assessment in achievement in mathematics showed no significant difference between students taught in the morning and students taught in the afternoon.

Implications and Areas for Future Research

The time is right for changes in how the school day is structured in order to take better advantage of all available classroom time. With the increasing demands placed on teachers to help students achieve more, one solution may be to use time in the classroom more effectively.

The research completed in the area of time-of-day effects on memory, attention and scholastic achievement can help, but there is a need for more practical research.

State standards prioritize mathematics and language arts as the two main curricular areas of importance in elementary school. These subjects are the areas that the NCLB examines to assess how students and schools are performing. There is a fair amount of research that examines the time-of-day effects on student memory, attention, and scholastic achievement in the area of language arts, but research that examines a best time-of-day for students to study mathematics is scant.

The two components of teaching mathematics are computational skills and problem solving skills. According to Russell (2000, p. 154), efficiency, accuracy and flexibility are the three characteristics of computational skills. Using computational skills in performing algorithms are of “great practical and theoretical importance” (Bass, 2003, p. 323). Furthermore, without these foundation skills, problem solving will be more difficult. In fact, it is important to acknowledge that computational skills are just as important as conceptual skills.

The same cognitive functions that are used by the brain in language arts (attention, using working memory, as well as accessing long-term memory storage) are essential for learning mathematics. Although these cognitive functions may be used to a greater or lesser degree during mathematics than during language arts, the studies that examine time-of-day effects on language arts can be extended to see how memory and attention may be affected in the area of mathematics.

Improvements in learning and retaining of mathematics skills may not be achieved simply by teaching for longer periods of time. Students have a finite attention span and the brain needs time to process new thinking. Trying to pack more information into a student's brain is futile. Instead, structuring mathematics instruction into a couple of blocks during the day may be a smarter solution. Because learning a new mathematics skill relies largely on short-term memory, it would seem logical to teach new concepts in the morning when short-term memory is strongest. It also would seem logical to use the afternoon instructional time to practice skills previously taught. Because practice (rehearsal) is needed to make learning permanent and new information is in long-term memory only after at least 24 hours have passed, then it would be a good idea to review and practice skills taught over 24 hours ago during the afternoon when learning new concepts may be more difficult. This will give students time to learn new concepts in the morning and practice older concepts in the afternoon.

New research involving time-of-day effects and mathematics has the potential to add new pieces to the puzzle of best practices for teaching.

Methods and Procedures

This study approaches investigating math in a practical way, by looking at an important part of teaching math: practice of an already-learned skill. Are students better able to focus their attention at certain times of the day or are students able to focus their attention equally well throughout the day? By understanding the answer to this question, teachers can evaluate whether the timing and methods they are currently using for teaching math should be altered so that students can learn more effectively. To investigate this question, this study used an explanatory mixed methods design.

The research question that guided this research was: To what extent might time-of-day influence students' ability to concentrate and be accurate in math computation? The students in this study took a series of quizzes during three different time periods (morning, mid-morning, and afternoon) over a period of three weeks. These quizzes were comprised of ten similar addition problems and tested their ability to perform an already-learned skill (the skill of addition with regrouping). By testing a skill they have already learned, this study examined their accuracy on the quizzes, as well as observed the concentration levels of the students. The times to give the quizzes were chosen to accommodate the school site's scheduled recess and lunch breaks. The times were also chosen to give time for the students to settle in after they arrive at school in the morning or return to the classroom from recess or lunch.

Examining the scores on the quizzes helped answer the question about accuracy; and that information, along with field note observations, may imply whether or not students are able to concentrate equally throughout the day. However, this data may not necessarily reveal the reasons for the findings. To accomplish this, students filled out a reflective questionnaire on how they perceived their concentration levels to be at different times of the day. This qualitative aspect helped explain the quantitative results of the quiz scores and further the understanding of use of class time at the practical level.

Sample and Site

The participants in this study are the 20 third grade students in a self-contained classroom. The site is an elementary school with a population of 613 students in a suburban area. The ethnicities of the students are: American Indian (1.3%), Asian (11.9%), Pacific Islander (1.8%), Filipino (3.4%), Hispanic (12.2%), African *American* (3.7%), White (63.3%), and multiple/no response (2.4%).

Access and Permissions

Permission from the principal of the site was obtained using the Administrator Release Form (Appendix A). Permission from the parents of the students in this study was obtained using the Student Release Form (Appendix B).

Data Collection

This study used an explanatory mixed methods research design to collect quantitative and qualitative data. The emphasis of data collection was quantitative with a smaller qualitative aspect to help explain the findings of the quantitative data.

The quantitative aspect involved students taking a series of quizzes comprised of ten addition problems, each problem consisting of adding three, three-digit numbers. The numbers on the quizzes were produced by generating them using a random number generator (http://www.random.org/nform.html). The quizzes schedule was as follows:

Week 1	9:30 a.m. Monday	11:30 a.m. Wednesday	1:30 p.m. Friday
Week 2	1:30 p.m. Monday	9:30 a.m. Wednesday	11:30 a.m. Friday
Week 3	11:30 a.m. Monday	1:30 p.m. Wednesday	9:30 a.m. Friday

The same quizzes were given on each Monday, Wednesday, and Friday respectively, but the order of the numbers within the problems, as well as the order of the problems, was changed. This way, a comparison of students' accuracy at different times of the day can more easily be made, for they did the same problems three times, but at different times of the day. During the quizzes, observational notes were taken on how the students' ability to settle in to taking the quizzes and their ability to focus on the task.

Each student was assigned an identification number, which he/she used on all quizzes and the questionnaires. This way a comparison of the data for different times of the day for each student can be made. The quiz numbers that appear at the top of the problem sheet corresponds to the testing day and time to be sure that the samples can be identified for each day and time period.

For the qualitative aspect, the students filled out a questionnaire after the final quiz has been taken on each Friday. The questionnaire asked students to reflect upon on which time-of-day did it seem easiest for them to concentrate on the quizzes.

Data Analysis

Before analysis of the quantitative data, the quizzes were scored and assessed the data for missing or unusable data. The raw data (score on quiz versus time-of-day) was graphed for each time-of-day tested. This gives a sense of the distribution of the data. Microsoft Excel (version 11.0) is used for all statistical calculations. First, measures of central tendency (mean) and the standard deviation are calculated for each time-of-day tested (morning, mid-morning and afternoon) and compared the means to get a general sense of the data.

Next, the variance is calculated for each time-of-day of testing. The variance ratio is computed and used to determine if the variance in the scores is too widespread. If the variance ratio is under a certain value then the *analysis of variance (ANOVA)* test can confidently be used to determine if there is a statistically significant difference between mean test scores at different times of day. If the variance is not sufficiently homogeneous to support a standard *ANOVA* test, then the data will be transformed (using *arcsin* transformation), allowing application of *ANOVA* analysis.

Next, an *ANOVA* is performed on the data, which produces a number, F. This is a quantitative representation of the degree of difference between the means. For accepting or rejecting the null hypothesis, a significance value of $p = .05$ is used (Cresswell, p.188). If the critical value of F is less than the computed value of F, then the results are statistically significant and the null hypothesis is rejected. If the critical value of F is more than the computed value of F, then the results are not statistically significant and the null hypothesis is accepted.

If there is statistical significance, then *t-tests* are run on the data to determine where the significance lies. Running the *t-tests* pinpoints between which times there is statistical significance. The quantitative results are displayed in tables and the results are discussed.

After the analysis of the quantitative data is complete, the student questionnaires are analyzed. First, the questionnaires are read to obtain a general idea of how the students answered. The closed-ended questions are scored and notes on the open-ended questions are taken to start looking for trends concerning time-of-day. The observation field notes taken during the quizzes are read to look for any correlations with the student responses. After looking over the data several times, themes in their answers are constructed that may help to explain the results on their quizzes. The observation notes and student questionnaires are coded, according to these themes. These themes are formed into a narrative in conjunction with the quantitative data.

Ethical Standards

This study adheres to Ethical Standards in Human Subjects Research of the American Psychological Association (Publication Manual of the American Psychological Association, 2001). Additionally, this project was reviewed and approved by the Dominican University of California Institutional Review Board and was assigned the approval number 4001.

Results and Findings

Summary of Major Findings

Permission from the principal and parents of the students were obtained. One student did not participate in the study. Data collection for this project was conducted from Monday, September 19, 2005 through Thursday, October 6, 2005. Several changes were made in the data collection schedule to accommodate the students' schedule, as follows:

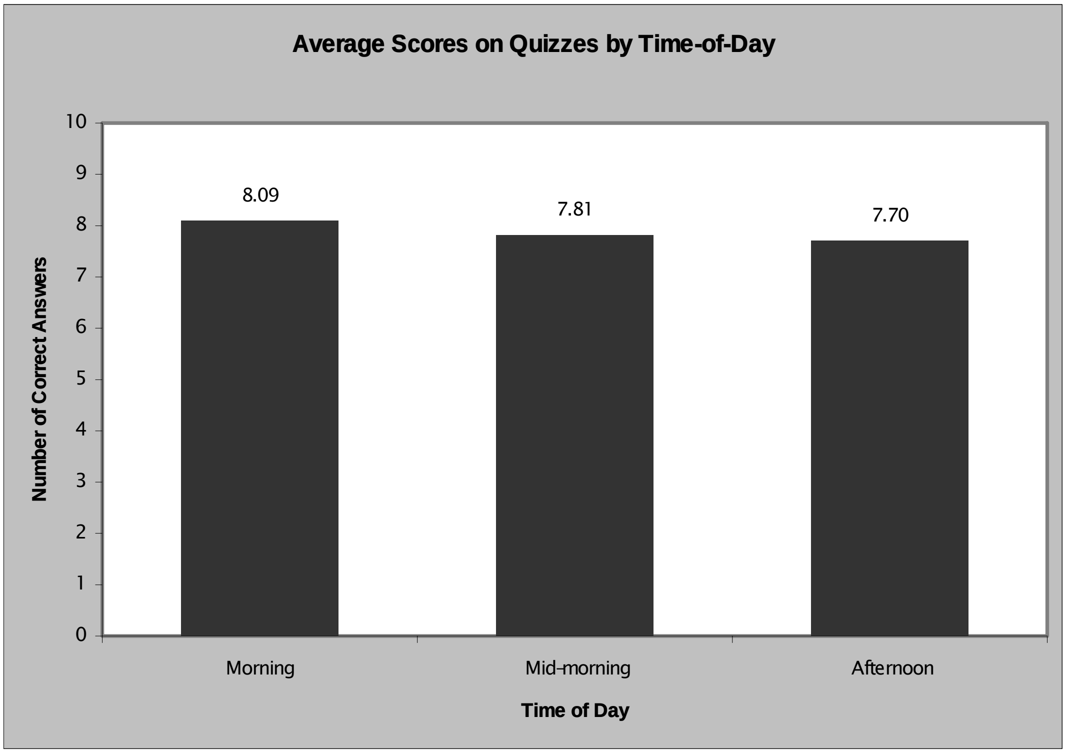
Week 1	9:30 a.m. Monday	11:30 a.m. Wednesday	1:30 p.m. Friday
Week 2	11:30 a.m. Monday	1:30 p.m. Wednesday	8:30 a.m. Friday
Week 3	1:30 p.m. Monday	9:30 a.m. Wednesday	11:30 a.m. Thursday

These minor changes to the schedule do not hurt the integrity of the study. The students took each of the quizzes during the early morning period, the mid-morning period and the afternoon period each week, for three weeks.

Each quiz was hand-scored and a score from zero through ten was recorded for each quiz. Microsoft Excel (version 11.0) was used for all statistical calculation. First, the raw scores were graphed to get a sense of the data. Next, the mean scores were graphed for each time-of-day: morning, mid-morning, and afternoon (see Figure 1). There is a slight trend toward students performing best during the morning time, followed by the mid-morning time, and lastly, the afternoon time.

Figure 1

Mean performance scores of students for morning, mid-morning, and afternoon testing times.



Next, the mean, standard deviation, and variance were calculated for each time-of-day (Table 1) to get a sense of the data. The homogeneity of the variance scores was analyzed by computing the variance ratio. The variance ratio was compared to the value of F_{max} in the Excel program. Because the computed ratio, 2.04 was less than the value of F_{max}, the *analysis of variance (ANOVA)* could confidently be performed to determine if there is a statistically significant difference between mean test scores at different times-of-day.

Table 1

Mean, standard deviation, and variance for morning, mid-morning, and afternoon testing times.

Time-of-Day	M	SD	Variance
Morning	8.09	1.63	2.65
Mid-morning	7.81	2.30	5.29
Afternoon	7.70	1.91	5.41

Next, an *ANOVA* was performed (see Table 2) and the value of *F* computed ($F= 0.57$). The *F* value was compared to the critical value of $F = 3.05$. This value uses a significance level of $p = .05$ (Cresswell, p.188). Because the *F* value for the results was less than the critical *F* value, the results are not statistically significant and the null hypothesis is accepted: that there is no statistical significance in student accuracy, based on time-of-day.

Table 2

Analysis of Variance for Performance on Quizzes at Three Times-of-Day

Source of Variance	df	SS	MS	F
Between groups	2	4.41	2.20	0.57
Within groups	158	609.85	3.86	
Total	160	614.26		

$p > .05$

After compiling the quantitative data, the qualitative data was analyzed: the student questionnaires and field notes taken during the quizzes. The results of the questionnaires can be seen in Table 3. The only time a student answered consistently was when they chose *no preference*. Three out of eighteen students chose this answer every week for three weeks. Otherwise, students chose two or three different time periods (or *no preference*) as the time when he or she could concentrate best.

Table 3

Students' Time-of-Day Preference for Concentration

	Number of students who chose time period as their best time of concentration			
	Week 1	Week 2	Week 3	Totals
Morning	5	7	1	13
Mid-morning	4	1	6	11
Afternoon	3	2	3	8
No Preference	5	8	8	21

After coding the responses, several themes emerged regarding the explanations of students who chose a particular time period as their time of best concentration (if they had a preference). The underlying themes can be seen in Table 4.

Table 4

Students' Explanation of Best Level of Concentration

	Physical Factors	Environment/ Ecology	Concentration Level	Practice
Morning	4	3	3	1
Mid-morning	1	3	1	2
Afternoon	3	1	0	0
Totals	8	7	4	3

Finally, how often students were able to predict when their highest level of concentration was during the quizzes was analyzed. This was done by comparing their highest quiz score for the week to the time-of-day they indicated as their time of best concentration. Students correctly assessed when they could concentrate best eight times out of the fifty-three (or 15%). Twenty-one out of fifty-three times (40%) students stated *no preference* as to when they could concentrate best.

The qualitative data appears to support the findings of the quantitative data. Students selected the morning time more often than mid-morning and afternoon as their time of highest concentration. Mid-morning was the next time period chosen, and finally, afternoon was chosen the least often. It is important to note that even though the trends of student-picked times for best concentration follow the trend of which time period students performed the best on the quizzes, the times chosen on the student questionnaires were not necessarily chosen by the actual students who performed better at that time.

Discussion

Summary of Major Findings

Although there was a slight trend toward students performing the best in the morning, followed by the mid-morning, and finally the afternoon, the results did not show a statistical significance between student scores on the quizzes and the times of day that the quizzes were taken (based on the ANOVA results). The null hypothesis, that there is no statistical significance in student accuracy, based on time-of-day, is therefore rejected.

The student questionnaires support the findings of the quantitative results. Students' chosen time of best concentration level follows the same trend as the scores on the quizzes, that is that the best time of concentration was in the morning, followed by the mid-morning and finally the afternoon times. It is important to note, however, that the students who chose a particular time-of-day as their best concentration time, was not necessarily correct.

None of the students in this study consistently chose one time-of-day as their best time of concentration on the quizzes. Some students were really tuned in to their physical comfort level. If they were feeling alert and/or not hungry (physiological factors), they felt they could concentrate better. Other students mentioned things like the classroom being cool or quiet or the fact that it was during regular math time that helped them feel they were concentrating better (classroom ecology/environment factors). A few students noted that they felt more alert at a particular time, but that specific time changed for them over the three weeks of data collection. The only conclusion that can be drawn from the student questionnaires is that students had a variety of reasons as to why they thought they were concentrating the best at a particular time of day. Also, students were not able to determine when their concentration level was best with much accuracy.

The field notes taken during the quizzes indicate similar findings. Students felt they were better able to concentrate because of a variety of reasons. Knowing the individual students behavior patterns helped reveal see why they were behaving in certain ways. Students who were not confident in math fidgeted and avoided taking the quizzes at first. Their time to complete the quizzes, as well as their accuracy, improved over the course of the data collection. Students who were experiencing a difficult time emotionally (e.g. best friend moving away) also had a difficult time concentrating on the quizzes. Similarly, students who did not receive enough sleep or were hungry also had a difficult time completing the quizzes within a reasonable amount of time (15 minutes). The top math students (determined by their end-of-year standardized test scores) scored consistently well (9 or 10 points) on all the quizzes, although many of them indicated a time when they felt they could concentrate better.

Piecing this all together makes it evident that teachers are teaching students and not a particular subject matter. Teachers can do their part by creating an effective working classroom environment, but if students are experiencing physiological or emotional concerns, then anything a teacher does may not help the student to be able to concentrate on a particular task. In short, every student is an individual with individual concerns and needs. If these needs are not met, then participating in school may be difficult. The student's ability to perform and concentrate in school is linked to many factors. It may be may be that these other factors override time-of-day influences in these third grade students.

Comparison of Results/Findings with Existing Studies

The quizzes that the students took in this study use both working memory and long-term memory functions. Early studies (Laird, 1925: Blake, 1967; Baddeley, Hatter, Scott, and Snashell, 1970; Hockey, Davis, and Gray, 1972) concluded that short-term memory was stronger in the morning than in the afternoon. This study did not specifically study short-term memory, so the results of this study neither support nor not support their findings.

Previously conducted studies investigating long-term memory and time-of -day (Baddeley, Hatter, Scott, and Snashell, 1970; Hockey, Davis, and Gray, 1972), concluded that long-term memory was stronger in the afternoon than in the morning. The results of this new study do not support their findings. Assuming that this study tested long-term memory retrieval to complete the quizzes, then the results of this study oppose earlier findings. Although the results of this study were not found to be statistically significant, there is a slight trend in the average scores during each time period (morning, mid-morning, and afternoon) to decrease over the course of the day. The results of this study show a slight trend in students' accessing long-term memory to be decreasing from morning to mid-morning and from mid-morning to afternoon. This is opposite of what was expected, based on previous studies. It should be noted that it is unclear if these earlier studies were accurately testing long-term memory retrieval or in fact, testing short-term memory retrieval.

Studies that truly tested long-term memory retrieval (Folkard, Monk, Bradbury and Rosenthall, 1977; Millar, Styles, & Wastell, 1995) found that long-term memory is stronger in the afternoon than in the morning. The results of this new study do not support their findings. The Folkard, Monk, Bradbury and Rosenthall (1977) study examined the time-of-day of initial learning whereas this study investigated time-of-day of retrieval from long-term memory. Because this study examine a previously-learned skill, it is not possible to determine at what time-of-day they learned this skill, and therefore not possible to compare results.

The results of this new study does support the findings that time of testing does not appear to be as important as the time at which the learning was achieved (Folkard, Monk, Bradbury and Rosenthall, 1977; Peters, 1984). The students learned how to perform the addition algorithm over a long period of time during the second grade, so this study solely investigated their ability to concentrate on performing this previously-learned skill. The findings of this new study challenge the idea that testing students in the morning for the purposes of accurate assessment of their learning may not be necessary.

Limitations of the Study

It was important to keep this study size small because of the qualitative component; it was important to be familiar with the student's typical behaviors in conjunction with the observation during the quizzes. This study was limited in its sample size of eighteen. This study was also limited by the demographics, which are specific to this site, as well as the geographic location. Because the students in this study are all in third grade, it is another limitation to this study. Finally, this study was also limited by the contents of the quizzes as students were only asked to perform a previously-learned addition algorithm.

Implications for Future Research

Including students of different ages/grades, demographics, and geographical location could further research in this area of mathematics and time-of-day influences. Another logical next step would be to investigate other components of mathematics such as problem solving or newly-learned subject matter. By studying newly-learned subject matter, the link between time-of-day, short-term memory and mathematics could be examined.

Another way to expand this research could be to lengthen the study. Students in this study were accustomed to doing mathematics during the first two testing periods (morning and mid-morning), but not during the afternoon time. If students became accustomed to doing mathematics during any time of the day, then the results of a study like this one could be more meaningful.

It would also be interesting to examine the results of student performance according to their achievement level and time-of-day effects. Do differently achieving students perform differently on mathematics at different times of the day? It is certain that more research is needed in the area of mathematics and time-of-day influences to form a clearer picture of best classroom practices.

Overall Significance of the Study

This study sought to provide more information on time-of-day influences on student performance in mathematics. The fact that the time-of-day influences were found not to be significant in this study leads to the question of why some teachers and students feel students should be taught core subjects in the morning hours. The results of this study suggest that students who come to school with their physiological factors met (adequate food and sleep) could perform mathematics accurately at any time of the day. The other component of student success is teacher attitude and expectations. If the classroom environment and ecology are conducive to student learning, then perhaps students could perform mathematics accurately at any time of the day. If it is true, as the results of this study suggests, then teachers have the freedom to plan math in a variety of ways to improve student learning and retention of learning.

One way in which to implement the findings of this study with earlier research and would be to use the morning time to teach new mathematics concepts and the afternoon to review already-learned concepts. This combines the idea that students learn better if learning time is broken down into shorter segments with the notion that short-term memory is stronger in the morning and long-term memory is stronger in the afternoon.

With every new piece of research in this area, a clearer idea best teaching practices emerges, to the benefit of teachers and students alike.

References

Baddeley, A.D., Hatter, J.E., Scott, D., & Snashell, A. (1970). Memory and time of day. *Quarterly Journal of Experimental Psychology, 22*, 605-609.

Barron, B.G. et al. (1994). Effects of time of day instruction on reading achievement of below grade readers. *Reading Improvement*, *31(1)*, 59-60.

Bass, H. (2003). Computational fluency, algorithms, and mathematical proficiency: one mathematician's perspective. *Teaching Children Mathematics*, *9(6)*, 322-327.

Blake, M.J.F. (1967). Time of day effects on performance in a range of tasks. *Psychonomic Science 9(6)*, 349-350.

Blake, M.J.F. (1971). Temperament and time of day. In W.P. Colquhoun (ed.), *Biological Rhythms and Human Performance*. New York, NY: Academic Press.

Caine, R.N. (2000). Building a bridge from research to classroom. *Educational Leadership*, *58(3)*, 59-61.

Caine, R.N. & Caine, G. (1998). Building a bridge between the neurosciences and education: cautions and possibilities. NASSP Bulletin, 82(598), 1-8. Retrieved February 19, 2005, from http://newfirstsearch.oclc.org/images/ WSPL/wsppdf1/HTML/01571/2OVB6/GSp.HTM

Cresswell, J.W. (2005). *Educational research: planning, conducting, and evaluating quantitative and qualitative research* (2nd ed.). Upper Saddle River, NJ: Pearson Education, Inc.

Davis, Z. (1987a). Effects of time-of-day of instruction on beginning reading achievement. *Journal of Educational Research, 80(3)*, 138-140.

Davis, Z. (1987b) The effects of time-of-day instruction on eighth grade students' English and mathematics achievement. *The High School Journal, 72(2)*, 78-80.

Dunn, R., Dunn, K, Primavera, L., Sinatra, R., & Virostko, J. (1987). A timely solution: effects on chronobiology on achievement and behavior. *Clearing House, 61(1),* 5-8.

Folkard, S. & Monk, T.H. (1980, May). Circadian rhythms in human memory. *British Journal of Psychology, 71(2),* 295-307.

Folkard, S. Monk, T.H., Bradbury, R., & Rosenthall, J. (1980). A note on "time of day effects in school children's immediate and delayed recall of meaningful material"- the influence of the importance of the information tested. *British Journal of Psychology, 71(1),* 95-97.

Folkard, S. Monk, T.H., Bradbury, R., & Rosenthall, J. (1977). Time of day effects in school children's immediate and delayed recall of meaningful material. *British Journal of Psychology, 68(1),* 45-50.

Haahr, Mads. (1999). Web Interface to the True Random Numbers [Computer software]. Retrieved July 5, 2005 from http://www.random.org/nform.html

Hockey, G.R.J., Davies, S. & Gray, M.M. (1972). Forgetting as a function of sleep at different time of day. *Quarterly Journal of Experimental Psychology, 24(4),* 386-393.

Jensen, E. (2000). *Brain-based learning: the new science of teaching & training* (Rev. ed.). San Diego, CA: The Brain Store.

Klein, J. (2001, September). Attention, scholastic achievement and timing of lessons. *Scandinavian Journal of Educational Research, 45(3),* 301-309.

Laird, D.A. (1925). Relative performance of college students as conditioned by time of day and day of week. *Journal of Experimental Psychology 8*, 50-63.

Marzano, R. (2002, January). In search of the standardized curriculum. *Principal (Reston, VA), 81(3)*, 6-9.

Muyskens, P. & Ysseldyke, J.E. (1998, Winter). Student academic responding time as a function of classroom ecology and time of day. *The Journal of Special Education*, 31, 411-424. Retrieved February 18, 2005, from WilsonSelectPlus database.

Oakhill, J. (1988). Text memory and integration at different times of day. *Applied Cognitive Psychology*, *2(3)*, 203-212.

Popham, W.J. (2003). Living (or dying) with your NCLB tests. *School Administrator, 60(11),* 10-14.

Rose, L.C. (2004, Winter). NCLB: failed schools--or failed law? *Educational Horizons, 82(2)*, 118-168.

Russell, S. (2000). Developing computational fluency with whole numbers. *Teaching Children Mathematics, 7(3),* 154-158.

Schmoker, M. & Marzano, R. (1999, March). Realizing the promise of standards-based education. *Educational Leadership, 56(6),* 17-21. Retrieved February 20, 2005, from WilsonSelectPlus database.

Sousa, D.A. (2001). *How the brain learns* (2nd ed.). Thousand Oaks, CA: Corwin Press, Inc.

Sylwester, R. & Cho, J-Y. (1992/1993, December/January). What brain research says about paying attention. *Educational Leadership, 50(4)*, 71-75.

WestEd Policy Brief (2001, Winter). Making time count. Retrieved February, 22, 2005, from http://www.WestEd.org/policy

Appendix A: Quizzes

Student Identification # ________

Quiz #1

$$\begin{array}{r} 185 \\ 915 \\ +\ 818 \\ \hline \end{array} \qquad \begin{array}{r} 616 \\ 331 \\ +\ 633 \\ \hline \end{array} \qquad \begin{array}{r} 371 \\ 403 \\ +\ 518 \\ \hline \end{array}$$

$$\begin{array}{r} 585 \\ 705 \\ +\ 757 \\ \hline \end{array} \qquad \begin{array}{r} 862 \\ 617 \\ +\ 450 \\ \hline \end{array} \qquad \begin{array}{r} 312 \\ 474 \\ +\ 377 \\ \hline \end{array}$$

$$\begin{array}{r} 313 \\ 508 \\ +\ 563 \\ \hline \end{array} \qquad \begin{array}{r} 574 \\ 254 \\ +\ 909 \\ \hline \end{array} \qquad \begin{array}{r} 789 \\ 204 \\ +\ 381 \\ \hline \end{array}$$

$$\begin{array}{r} 198 \\ 781 \\ +\ 186 \\ \hline \end{array}$$

Student Identification # ________

Quiz #2

758	121	988
914	152	780
+ 692	+ 569	+ 997
998	134	889
589	336	635
+ 229	+ 373	+ 908
860	944	338
674	776	552
+ 735	+ 736	+ 380
425		
245		
+ 642		

Student Identification # ________

Quiz #3

$$\begin{array}{r} 780 \\ 917 \\ \underline{+\ 928} \end{array} \qquad \begin{array}{r} 235 \\ 707 \\ \underline{+\ 821} \end{array} \qquad \begin{array}{r} 704 \\ 747 \\ \underline{+\ 383} \end{array}$$

$$\begin{array}{r} 892 \\ 915 \\ \underline{+\ 905} \end{array} \qquad \begin{array}{r} 631 \\ 157 \\ \underline{+\ 793} \end{array} \qquad \begin{array}{r} 944 \\ 706 \\ \underline{+\ 148} \end{array}$$

$$\begin{array}{r} 755 \\ 496 \\ \underline{+\ 260} \end{array} \qquad \begin{array}{r} 108 \\ 590 \\ \underline{+\ 833} \end{array} \qquad \begin{array}{r} 315 \\ 836 \\ \underline{+\ 813} \end{array}$$

$$\begin{array}{r} 355 \\ 692 \\ \underline{+\ 579} \end{array}$$

Student Identification # ________

Quiz #4

705 757 + 585	474 377 + 312	781 186 + 198
789 204 + 381	331 633 + 616	508 563 + 313
403 518 + 371	915 818 + 185	254 909 + 574
617 450 + 862		

Student Identification # ________

Quiz #5

245	589	674
642	229	735
+ 425	+ 998	+ 860
552	635	914
380	908	692
+ 338	+ 889	+ 758
336	776	152
373	736	569
+ 134	+ 944	+ 121
780		
997		
+ 988		

Student Identification # ________

Quiz #6

915 905 + 892	706 148 + 944	496 260 + 755
590 833 + 108	707 821 + 235	836 813 + 315
917 928 + 780	747 383 + 704	692 579 + 355
157 793 + 631		

Student Identification # ________

Quiz #7

757
585
+ 705

633
616
+ 331

563
313
+508

450
862
+ 617

186
198
+ 781

377
312
+ 474

518
371
+ 403

909
574
+ 254

381
789
+ 204

818
185
+ 915

Student Identification # ________

Quiz #8

736	692	380
944	758	338
+ 776	+ 914	+ 552
735	229	642
860	998	425
+ 674	+ 589	+ 245
373	908	569
134	889	121
+ 336	+ 635	+ 152
997		
988		
+ 780		

Student Identification # ________

Quiz #9

813 315 + 836	579 355 + 692	148 944 + 706
833 108 + 590	793 631 + 157	821 235 + 707
383 704 + 747	260 755 + 496	928 780 + 917
905 892 + 915		

Appendix B: Student Questionnaire

Student Identification # ________

Student Questionnaire

Please circle the time-of-day you concentrated the best on the quizzes.

Week 1

a. 9:30 a.m. b. 11:30 a.m. c. 1:30 p.m. d. No preference

Why do you think that is?

____

____

____

Week 2

a. 9:30 a.m. b. 11:30 a.m. c. 1:30 p.m. d. No preference

Why do you think that is?

____

____

____

Week 3

a. 9:30 a.m. b. 11:30 a.m. c. 1:30 p.m. d. No preference

Why do you think that is?

____

____

____

Appendix C: Observation Field Notes

Observer: ____

Quiz #: ____

Date and time: ____

Setting: ____

Length of Observation: ____

Descriptive Notes	Reflective Notes
Before the quiz (Are the students able to settle down?)	Before the quiz
During the quiz (Are the students able to focus their attention?)	During the quiz
Other observations	Other observations