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Students' Confidence in the Ability to Transfer Basic Math Skills in Introductory Physics and Chemistry Courses at a Community College

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The University of Southern Mississippi

STUDENTS' CONFIDENCE IN THE ABILITY TO TRANSFER BASIC MATH SKILLS IN INTRODUCTORY PHYSICS AND CHEMISTRY COURSES AT A COMMUNITY COLLEGE

by

Reginald Quinn

Abstract of a Dissertation
Submitted to the Graduate School
of The University of Southern Mississippi
in Partial Fulfillment of the Requirements
for the Degree of Doctor of Philosophy

May 2013

ABSTRACT

STUDENTS' CONFIDENCE IN THE ABILITY TO TRANSFER BASIC MATH SKILLS IN INTRODUCTORY PHYSICS AND CHEMISTRY COURSES AT A COMMUNITY COLLEGE

by Reginald Quinn

May 2013

The purpose of this study was to examine the confidence levels that community college students have in transferring basic math skills to science classes, as well as any factors that influence their confidence levels. This study was conducted with 196 students at a community college in central Mississippi. The study was conducted during the month of November after all of the students had taken their midterm exams and received midterm grades.

The instrument used in this survey was developed and validated by the researcher. The instrument asks the students to rate how confident they were in working out specific math problems and how confident they were in working problems using those specific math skills in physics and chemistry. The instrument also provided an example problem for every confidence item.

Results revealed that students' demographics were significant predictors in confidence scores. Students in the 18-22 year old range were less confident in solving math problems than others. Students who had retaken a math course were less confident than those who had not. Chemistry students were less confident in solving math problems than those in physics courses. Chemistry II students were less confident than those in

Chemistry I and Principals of Chemistry. Students were least confident in solving problems involving logarithms and the most confident in solving algebra problems. In general, students felt that their math courses did not prepare them for the math problems encountered in science courses. There was no significant difference in confidence between students who had completed their math homework online and those who had completed their homework on paper.

The researcher recommends that chemistry educators find ways of incorporating more mathematics in their courses especially logarithms and slope. Furthermore, math educators should incorporate more chemistry related applications to math class. Results of hypotheses testing, conclusions, discussions, and recommendations for future research are included.

The University of Southern Mississippi

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A Dissertation
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of The University of Southern Mississippi
in Partial Fulfillment of the Requirements
for the Degree of Doctor of Philosophy

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CHAPTER I

INTRODUCTION

Students entering the community college come from diverse backgrounds. Many students who enter the community college have vastly different backgrounds than the typical student entering a major university. In addition to the traditional college students who many universities attract, there are students who apply to the community college who have dropped out of high school and have only a general equivalence diploma (Barnes, 2010). Consequently, 55% of these students will take developmental courses upon registration (Sanders, 2004). Other community colleges, some in Iowa, have programs in which students can take classes to prepare for the general equivalence degree prior to enrollment (Ryder & Hagedorn, 2012). These students having to take so many noncredit developmental courses resulted in them taking longer to complete their college degree than students entering with a high school diploma.

In Mississippi, students graduating from college have to take at least six hours of natural science courses and three hours of mathematics (equivalent to college algebra or higher) regardless of their major (Mississippi Institutions of Higher Learning, 2012). For many non-science majors the class may be physical science, astronomy, chemistry, physics, computer science, or biology. Many non-science majors enrolling in the community college lack the necessary mathematical preparation to succeed in physical science, physics, and chemistry, as shown with the need to take remedial math courses. Even after taking remedial math courses or having the equivalent in high school, there are still many non-science majors who don’t have the adequate math background necessary to succeed in math based science classes (Sanders, 2004). This lack of preparation was illustrated in a study involving computer science (Beaubouef, 2002). The Beaubouef study was a synthesis of research studies done on students taking computer science courses along with the many issues students have in succeeding in computer science courses. In this study, Beaubouef highlighted the importance of why students need mathematics to succeed in computer science and she also explained how a large portion of students who take computer science have poor math skills (Beaubouef, 2002). The importance of mathematical preparation for computer science was illustrated when Beaubouef concludes “mathematics and problem solving go hand and hand, and students must develop these skills to succeed at systems analysis, design, programming, and testing” (p. 57). The Beaubouef study is just one of many studies that illustrate the importance of mathematics in science achievement. More details on the importance of mathematics in science (as transfer) are elaborated in chapter two.

Amongst science majors, there are students whose majors are not heavily math based, such as pre-medicine, pre-veterinary science, pre-dental, and pre-pharmacy. For many of the professional schools that these students intend to apply, math based subjects such as physics and chemistry are typically required when applying for admission (AAMC, 2012). As an example, the Association of American Medical Colleges lists one year of biology, physics, English, and two years of chemistry as the requirements that most medical schools have for admissions (AAMC, 2012). Therefore, a general physics (algebra based) and general chemistry class at a typical community college will include many of these pre professional majors with weak math backgrounds. Many universities have taken notice to this stark reality and have required mathematics in the course requirements for biology majors (e.g. Cornell, 2012). At Cornell University, biology majors are required to take at least one semester of calculus (Cornell, 2012). The physics and chemistry course requirements of the AAMC, and the growing requirements of universities requiring biology majors to take math classes beyond college algebra, facilitates the need for community colleges to focus on the mathematical background/preparation of these majors prior to taking physics and chemistry classes. The Cornell curriculum is just one example of a recent trend in requiring these students to take more mathematics. In summary, those students who plan to enter professional schools in which mathematics is not a central focus (e.g. medical school, dental school, veterinarian school, pharmacy school, physical therapy school, etc.) must have a solid math background to succeed in the math based science prerequisites (such as physics and chemistry) required for entry into these schools. In the following section, the researcher elaborated more on the need for math in chemistry and physics, but from the standpoint of those students who have chosen a math based science major (such as STEM majors).

Amongst math based science majors such as chemistry, physics, math, and engineering, the need for solid mathematical preparation is essential. In a study done on students' achievement in college physics, Champagne and Klopfer found that math ability and Newtonian physics accounted for 34% of the variance in achievement scores (Champagne & Klopfer, 1982). A similar trend is found with students taking physical chemistry (Becker & Towns, 2012). Becker and Towns (2012), was a study that examined if students could transfer mathematical knowledge of partial derivatives to thermodynamic problems in physical chemistry. This study and many other similar studies (Andresen & Lindenskov, 2009; Benander & Lightner, 2005; Boaler, 1993; Bottge et al., 2004; Britton, New, Sharma, & Yardley, 2005; Clark, 1993; Koedinger & McLaughlin, 2010; Leopold & Edgar, 2008; Potgieter, Harding, & Engelbrecht, 2008; Rebello et al., 2007) demonstrate the importance of mathematics in learning physics and chemistry. One study indicated that regardless of major (math based or not), some students will have difficulties with physics and chemistry because of their weak math skills (Basson, 2002). This study, Basson (2002), done with high school students (15-18 years old), assessing the results from the students' acceleration problems, illustrated how physics and mathematics relate when developing the physics concept of acceleration. In this study Basson notes:

> Students of all ages struggle with physics not only due to the complexities of the subject but also due to the inadequacies with their skills and knowledge of mathematics. (p. 679)

The Basson study together with the Chapagne and Kolpfer (1982) are just two studies that demonstrate a basic fundamental understanding of mathematics is not only essential in any study examining success in physics or chemistry, but mathematical ability can account for variance seen in achievement scores in those subjects (see Chapter II for more details and more studies).

Central to the present study is a student's confidence to transfer basic math skills to physics and chemistry. Transfer is defined by Bransford (2000) as "it allows the student to apply what was learned in new situations…" (p. 17). Many studies, outlined in Chapter II, show the importance for students to have the ability to transfer or apply their math skills to science. The Basson (2002) study concluded with this very point, as noted, "The connectedness and organization of different mathematics and science concepts should be enhanced and utilized" (p. 689). Another study that interviewed science teachers about students applying their math skills with Canadian high school seniors concluded (Nashon & Nielsen, 2007):

> because of the way mathematics is taught, students do not learn how to apply the math to physical situations [and this] leads to compartmentalization

of knowledge… Math is for math class (p. 97).

This same study found that all the science teachers agreed that students biggest problem with physics was applying their algebra skills to physics (Nashon & Nielsen, 2007). These studies show the prominence and strategic importance the transfer of mathematics plays in students' success in science classes.

It should be noted that the issue of students having problems transferring mathematics is not just limited to the traditional high school setting. Browne and Pecota (2007) did a study of cadets taking a navigation class at California Maritime Academy (a division of California State University) that involved applying mathematics and physics to maritime applications. The findings illustrate that cadets could not apply the math skills that they learned in the previous semester's math course to real world maritime problems (Browne & Pecota, 2007). The Browne and Pecota study revealed that students also had difficulties in applying or transferring basic math skills to maritime applications as well as to physics. More studies were elaborated on in chapter two; however, all of the collegiate studies reveal that students on the collegiate level have problems transferring math skills to science classes.

For the present study, the researcher's intent was to analyze students' confidence in their ability to transfer basic math skills to physics and chemistry. Confidence, in this study was defined in the context of self-efficacy. Self-efficacy is defined as "belief in one's capability" (Becker & Gable, 2009, p. 3). Confidence is defined as "the quality or state of being certain" (Merriam Webster, n.d.). In the context of this study, the researcher was interested in examining the students' self-efficacy, but more specifically, the researcher was interested in the students' certainty of the belief of their ability to transfer mathematics to Physics and Chemistry. For this study the researcher defined confidence the certainty in one's belief in their ability. By examining confidence, this study had taken a different approach from the previous studies that examined ability. In terms of ability, much of the research seemed to be conflicted on students' math background and that having a factor on their ability to transfer. As an example, a study by Lebeau, et. al (2012) conducted in an upper Midwest college, with 3500 students from 229 high schools, analyzed the math preparation students had in high school to see if that was a predictor for how well they performed in their chosen STEM field. The researchers concluded that most students were "equally prepared for the rigorous mathematics coursework, regardless of the high school mathematics curriculum" (p. 1). This study finds that the high school mathematics curriculum was not a predictor in how well students would do in their STEM fields. This result presumed they have the minimum mathematics necessary for the course they are took, but this study failed to explain those students who were not STEM math based majors such as the pre-medicine, pre-veterinarian, and other biological sciences. In the closest study to a community college setting, a study performed by Bahr (2008) concluded that students taking remedial classes have similar outcomes as students who have gone the traditional route in terms of grades or scores. This study, as well as Lebeau's study did not take into consideration the students' confidence as a possible indicator of success. The next study indicated that confidence was an indicator in academic achievement.

Rountree, Rountree, and Robins (2002) performed a study on predictors for success of first semester computer science students. The students answered a survey regarding expectations and their results were matched with their final grade (Rountree, Rountree, & Robins, 2002). The results from this study demonstrated that the largest and strongest factor of success was a student "expecting to get an A from the course"

(Rountree, et. al, 2002). By the students self reporting what grade they 'expect' to get out of the course, this is clearly the same as measuring the students' confidence in their performance in the course ('expecting an A', would correlate to a high level of confidence in the ability to perform in the course). Due to these results, the researcher decided to apply the idea of examining confidence in analyzing the students' ability to transfer math skills in physics and chemistry.

Currently, there does not appear to be any studies in the research that addresses students at the community college level and their confidence in the ability to transfer basic math skills to physics and chemistry. A few studies seem to measure achievement from various test scores as an indicator of mathematical transfer, but those studies do not include confidence and many are done at a high school or university level. These studies lack the student body unique to many community colleges as previously mentioned. The focus on the present study will involve confidence in transfer of the basic math skills needed for Physics and Chemistry, specifically targeting a community college population. Most of the latter studies that involve universities do not account for basic math skills, which was determined to be the main contributing factor as to why students at a university physics class did poorly in physics (Thomas, Wilkinson, Marr, Thomas, & Buboltz, 2001). That research involved students in an engineering university taking an electromagnetism course and in trying to improve the class, the researchers found that "poor performance was determined to result from a lack of fluency on lower-level skills.." (p. 2245). The Thomas et al. (2001) study and many similar to it, exemplify why research is needed in examining if students have confidence in applying basic math skills to physics and chemistry classes at the community college. Furthermore, Potgieter et al. (2008) concluded that chemistry students may not have a problem transferring mathematics to chemistry, but instead it was the lack of understanding of graphing and connecting that to algebra resulted in the poor chemistry performance (Potgieter et al., 2008). This study provides evidence for the need to examine transfer as it relates to specific mathematics topics used in Chemistry (Potgieter et al., 2008). For this reason, the analysis of the present research study will examine the students' level of confidence in transfer abilities as it relates to various areas of mathematics required for physics and chemistry.

The previous studies also lack exploring the relationships or differences between students' confidence levels in applying math skills in physics and chemistry. Furthermore, research in this area does not address the specific basic math skills that students have the least or greatest confidence in applying math to science.

Statement of the Problem

The problem of this study is stated as follows: What are the factors (all of the independent variables used in this study as defined below) present in students having the confidence to transfer basic math skills to science classes at the community college? More specifically, what math skills do students report having the most or least confidence in? In what subject areas do students report the most or least confidence levels and what specific math skills correlate to those subjects? What factors contribute the most to the confidence levels reported by students and in what areas?

Research Questions

This research studied the following questions:

Question 1: What factors (Age, gender, enrollment status, science course currently taking, homework method, grades in previous math class, previous math class taken, retaking the present science class, midterm grade in this science class, current degree level, and hours of study) contribute the most and to what extent to students reported confidence levels in applying math skills?

Question 2: Which science classes (chemistry, physics (both calculus and algebra based), physical science, chemistry ii, physics ii (both calculus and algebra based), and principles of chemistry) do students report having the least and greatest confidence in applying math skills?

Question 3: Which math skills (fractions logarithms, ratios, slope, conversions, solving algebraic expressions, scientific notation, arithmetic operations, and graphing) do students have the most and least confidence in applying to science?

Question 4: Is there a relationship between confidence in the ability to transfer and the reported grade in the science course?

Question 5: What level of confidence do students have in the ability to do problems that utilize pure math skills?

Question 6: Do the student have the most or least confidence in transferring basic math skills to chemistry, physics, principles of chemistry, or physical science related applications.

Hypotheses

H_1: Age, gender, enrollment status, science course currently taking, homework method, grades in previous math class, previous math class taken, retaking the present science class, midterm grade in this science class, current degree level, and hours of study do not account for variance in the overall mean confidence score.

H_2: There is no significant difference in overall confidence scores between the science course currently taking (chemistry, physics (both calculus and algebra based), physical science, chemistry ii, physics ii (both calculus and algebra based), and principles of chemistry).

H_3: There is no significant difference between the repeated measures basic math skills (fractions logarithms, ratios, slope, conversions, solving algebraic expressions, scientific notation, arithmetic operations, and graphing).

H_4: There is no significant difference in overall confidence scores between midterm grades in this science class.

H_5: There is no statistical difference in confidence between physics, chemistry, physical science, or principles of chemistry related confidence items.

Definition of Terms

The following is a list of terms and how they were defined in reference to this study.

Basic math skills – In this study, these are basic fundamental math skills forming the basis for the survey instrument (Appendix A) developed by the researcher. They are essential in science and include fractions, logarithms, ratios, slope, conversions, solving algebraic expressions, scientific notation, arithmetic operations, and graphing.

Confidence - In the context of this study, confidence is the students' reported certainty in the belief of their ability.

Confidence level – This is a numerical score computed from the survey instrument that is calculated from the mean of the scores from questions 15 through 44 relating to students confidence in applying math skills to science. These items were not designed to measure anxiety.

Demographic data – This is information pertaining to age, gender, education, and enrollment status.

Dependent variable – The variable in this study refers to confidence level of specific math skills or midterm average.

Homework method – the method in which homework was primarily done in the previous math class. The three methods under consideration in this study are paper and pencil, online, or a combination of paper and pencil with online homework.

Independent variable – This variable refers to demographic data, course taken, homework method, grades in previous math class, retaking the class, midterm grade, and hours of study.

Online homework – Refers to homework done using an online format. (e.g. webassign©, etc.)

Principles of chemistry – A chemistry class designed for those students who aren't prepared to take General Chemistry.

Pure Math Skills – The questions on the survey that measure confidence in the ability to do problems that *utilize mathematics only*. These items do not involve transfer to any of the science classes.

Science class – courses that include the following: Physics (Algebra-based), Physics (Calculus-based), Physics II (Algebra-based), Physics II (Calculus-based), General Chemistry (for science majors), General Chemistry II (for science majors), Principles of Chemistry, and Physical Science.

Traditional homework – Refers to homework that students do using paper and pencil.

Transfer - defined by Bransford (2000) as "it allows the student to apply what was learned in new situations…" (p. 17)

Delimitations

1. This study was limited to students at local community colleges in central Mississippi.

2. This study was limited to students taking classes during the day.

3. This study was also limited by the willingness of instructors and students to participate.

4. The study was limited to students' report of confidence.

Assumptions

This study assumed that the students have answered the questions in the survey in an honest and truthful manner.

Justification

The literature on transfer of mathematics to other areas is diverse. As previously shown, several of these studies examine the students' ability to transfer high level math skills to science classes at universities. Most of these studies show that ability varies. The other studies examine transfer at the k-12 level (Andresen & Lindenskov, 2009; Boaler, 1993; Bottge et al., 2004; Clarke, 1993; Koedinger & McLaughlin, 2010). These studies are not specific about which particular math skills that students transfer best and worse. If one wants to reform science or math classes so that students can better apply mathematics, it is important that the reformer knows which math skills students have the most difficulty applying and which skills students have the least problems with applying to science.

The present study attempts to fill the void left by the previously mentioned research studies. This study examines community college setting, a setting that is lacking from the research on mathematics transfer to science. Many high school graduates, high school dropouts, non skilled unemployed workers, and other nontraditional students are now enrolling at community colleges in record levels (Provasnik & Planty, 2008). The researcher has anecdotal evidence of a growing number of nontraditional students enrolling at his community college since the recession of 2008. Many of these students have to take a science course for their major and because many have had a weak math background in the past or have been out of school for over 10 years, their mathematical background is critical for success in the science classes they will have to register for when they enroll. In order for community colleges to effectively meet this need, research needs to be done on the circumstances involved with these students and their confidence to transfer mathematics to science. The present study will reveal a statistical analysis of the students' confidence in transferring math skills to science classes. The results of this statistical analysis will allow researchers to focus more specifically on the areas of highest importance (those areas that have the highest or lowest significant means). The present research study, will seek to investigate the broader issues from a quantitative analysis and contribute to filling the void left by the gap in the present research concerning community college students.

The results from this study are very instrumental in reforming the curriculum in many science departments across the nation. This study investigated the specific basic math skill deficiencies that students reported having low confidence. This information will allow science and math education reformers at the community college level to reform math courses to correct these deficiencies so that students may have a better chance of succeeding in transferring basic math skills needed for science. The statistical analysis from this study will allow reformers to reform the curriculum to better focus on those areas this study has revealed are statistically the most critical on teaching transfer.

Furthermore, the results from this study could aid in developing math courses that will allow students to better apply their math skills to other subjects outside of the traditional sciences, such as maritime applications, epidemiology, statistics, automotive applications, business, finance, and accounting to name a few. The math skills surveyed in this study are also transferred to many other fields outside of the traditional academic sciences. By this study revealing which areas students are the least or most confident in transferring math skills, educators in the other fields can spend more or less time teaching for transfer based on the math skills that were the most statistically significant in the present study. Given the limited time frame educators have to cover material, it is imperative to have a broad comprehensive statistical analysis of which math skills students are the most or least confident in transferring to science classes. Furthermore, the results of this study will serves as a basis for future studies that examine the possibilities of alternate conceptions that students have regarding the math skills analyzed in this study. Skills that students report high confidence in transferring from this study, but perform poorly (as evident in future and present studies), will reveal the need for further research and present the need to research (perhaps more specific detailed qualitative studies on the most statistically significant math skill and science class taken) what (if any) misconceptions students have regarding those specific math skills. At this point, these future studies are only speculative and will only be worthwhile if a statistical study on confidence, such as the present study (a first of its kind) is done. Many educators regardless of their field can agree that it is critically important for students, regardless of major, to have the confidence and ability to apply basic math skills to different situations. Math is incorporated into just about every field, class, or occupation and having the confidence to transfer one's basic math skills is of up most importance to success. It was the intentions of this researcher to fill the void left by the current research regarding students and their confidence in math transfer at community colleges.

CHAPTER II

REVIEW OF THE LITERATURE

Introduction

The present study investigated the confidence community college students have in their ability to transfer basic math skills to Physics and Chemistry. Confidence, in the context of this investigation, was the students' reported certainty in the belief of their ability (Merriam Webster, n.d.). Transfer was defined in this study by Bransford (2000) as “it allows the student to apply what was learned in new situations” (p. 17). As discussed in chapter one, other studies have not investigated this phenomena within the context of the community college setting. Nor has the research investigated this within the context of confidence, particularly in the community college setting. In addition to not examining this phenomenon of transferring math skills in terms of confidence and the community college setting, but none of the previous research does so examining the range of specific math skills as this study does. Although many studies examine mathematics achievement, none of the studies examine confidence in ability to transfer mathematics to science class. However, the current literature does investigate factors that have been associated with achievement in mathematics. In light of the research objective, the review of literature presented in this research reflects research that underlies the factors that affect achievement in mathematics. Factors that influence achievement included theories on how students learn mathematics, how mathematics was taught, gender, age, enrollment status, homework method (online or traditional), previous background, and homework/study time. Because this work examined the students confidence in the ability to transfer, this literature review will also include research on transfer as well as research on achievement in thereof.

It was the intent of the researcher in this literature review to demonstrate through various studies how the above factors have been shown to influence mathematics achievement. Furthermore, because those factors have been shown to have an influence in achievement, they were used in the present study to investigate transfer. In addition to demonstrating that those factors influence achievement, the researcher has utilized this review of literature to illustrate the importance of transfer in learning mathematics.

Teaching and Learning Mathematics

Behaviorism and Constructivism (and their effect on the development on teaching for mathematics for transfer)

For this section of the literature review it was the intent of the researcher to examine various educational and psychological theories developed over time. The researcher has additionally examined how those theories have changed mathematics education. From a psychological perspective there are many theories that have impacted mathematics education. The two most influential theories that have and still influence mathematics education today are behaviorism and constructivism.

Of those two theories, one the earliest accepted scientific theory of learning was behaviorism (Ormrod, 2006). Behaviorism was developed in the early 1900's (Ormrod, 2006). The basic idea behind this theory is that people learn through stimulus and response associations (Ormrod, 2006). A consequence of this theory is reinforcement, in which, some reinforcement (positive or negative) is applied to encourage the learner to learn the desired behavior or concept (Omrod, 2006). Early behaviorist psychology includes the works of Ivan Pavlov. His research involved classically conditioning dogs to learn the behavior of salivating when a person or some signal that is associated with food is brought in the dog's presence (Pavlov, 1927). One of the most significant influences of

Behaviorism in Mathematics education comes later in the development of operant conditioning. BF Skinner's research is one of the earliest examples of operant conditioning (Ormrod, 2006). In operant conditioning a desired response is repeated when presented with reinforcement (Ormrod, 2006). This reinforcement has influenced mathematics education in the form of punishments and/or rewards. These developments in psychology demonstrated that a math teacher could get students to learn some desired concept in Mathematics by reinforcing (positively or negatively) the learning that the teacher desires. In Educational Psychology Ormrod (2006) suggests positive reinforcement to encourage students to learn mathematics (such as praise or encouraging the students to utilize intrinsic reinforcement). Those positive reinforcements have clearly influenced Mathematics education and continue to do so today. When a math teacher writes *excellent*, *good job*, *keep up the good work* on a student's graded assignment, that teacher has applied the behaviorist model of positive reinforcement.

Another aspect of mathematics education impacted by behaviorism is how students are taught. When students are taught mathematics through rote drill or memorization, research indicates that behaviorism is at play (Handal & Harrington, 2003). Many other teaching practices commonly used in traditional mathematics classrooms such as following procedures to solve problems or even the idea or using repetition to learn mathematics can be attributed to the behaviorist model of learning mathematics (Handal & Harrington, 2003).

In the mathematics classrooms of today many of the learning techniques used by teachers and students such as memorization, repetition, praise, and criticism have their origins in the behaviorist model of learning. Although effective on certain assessments, behaviorism in mathematics education is not without its limitations and disadvantages.

Behaviorism fails when reinforcements are not enough to motivate students to learn, behaviorism fails when reinforcements have the effect of teaching for efficiency and repetition as opposed to teaching for understanding, and behaviorism fails when extrinsic reinforcements conflict with the student's intrinsic reinforcements (Ormrod, 2006).

Another psychological theory is commonly accepted as an alternative to Behaviorism. This theory has been used to address the deficiencies of the behaviorist and cognitive models. Constructivism is one of the most commonly used theories in education today. Some of the earliest work on constructivism began with Jean Piaget and his research on the stages of development in children (Ormrod, 2006). In this research Piaget essentially discovered that children learn by constructing or making sense of their world (Ormrod, 2006). Piaget's work is embodied in the constructivist theory, in that learners "create meaning as opposed to acquiring it" (Ertmer & Newby, 1993, p. 63). Constructivism is seen in many dimensions of mathematics education. A number of research studies in math education stress teaching students by allowing them to solve problems and place minimum involvement on the part of the teacher in helping students solve those problems (Hiebert et al., 1997). Such an approach to teaching has a constructivist foundation, because the goal is to get students to learn mathematics by creating their own meaning of the subject in a way that makes sense to them. In *Making Sense*, Hiebert et al. (1997) stressed the importance of using this problem solving approach and touted the many benefits it has for students in learning mathematics for understanding (Hiebert et al., 1997). The constructivist model of the students making sense of mathematics is seen as early as the forties (Brownell, 1947). In the *Place of Meaning in the Teaching of Arithmetic* Brownell is one of the first mathematics educational researchers to advocate changing teaching arithmetic in which the students can make sense and meaning of what is being taught (Brownell, 1947). Although, not as radical as others to come in the "constructivist" period, Brownell's (1947) work was revolutionary for its time because it put an emphasis on teaching math in a way that made sense to the learner, with the idea that the learner would learn by making sense of the mathematics. Brownell's approach was in stark opposition to the rote memorization that was advocated by many of the math educators who supported the behaviorist model.

The other aspect of constructivism is the effect the social environment has on learning. One of the leaders in this area of constructivism was a Russian psychologist named Lev Vygotsky. His work with the effect the social environment has on learning includes the zone of proximal development (Bransford et al., 2000). Zone of proximal development puts an emphasis on learning a task with the help of someone else and gradually learning to do the task on one's own without the assistance of the instructor (Vygotsky, 1966). The effects of the social environment on learning mathematics are evident in the classroom today, especially in the context of cultural, socioeconomic, and gender inequities. Because students from different cultural backgrounds, have different experiences due to their social environment, researchers encourage math teachers to design the classroom with those considerations in mind (Hiebert et al., 1997). Unlike behaviorism, constructivism considers the learners prior knowledge. Therefore, in the process of constructing meaning from prior knowledge the social environment must be a consideration in teaching mathematics for understanding.

In conclusion, mathematics education has been deeply impacted by psychological and education theories. Behaviorist models influenced the math teaching techniques of rewards, punishments, reinforcements, and conditioning seen in mathematics classrooms.

Constructivism has influenced mathematics education with the recent developments in inquiry based learning, problem based learning, and others that emphasize teaching mathematics for understanding due to the knowledge construction aspect of constructivism. Because of the social environmental aspect of constructivism, mathematics education researchers generally promote classrooms that are socially equitable, the effects of this will become more evident in the gender section.

Effectively Teaching Mathematics (the development of themes argued for in transfer studies)

Of the various research available on teaching and learning mathematics, there seems to be several concepts that emerge. The first concept involves the focus on how mathematics is taught or the way in which one can effectively teach mathematics as opposed to teaching based solely on the teacher and his or her qualifications (Stigler & Hiebert, 2004). The second idea that emerges is an emphasis on teaching students mathematics in a manner that allows them to synthesize that knowledge to a variety of situations outside of the context in which they learned it.

Effectively teaching Mathematics is a theme that is consistently studied among math education researchers. In “Improving Mathematics Teaching”, Stigler and Hiebert (2004) did an analysis of the TIMSS study and found differences in the countries ranked high in the study and those that were not ranked very high (more specifically the United States). In this study it was found that the difference in scores was not attributed to whether a nation's teachers taught mathematics from a problem solving approach or a procedural approach (Stigler & Hiebert, 2004). The differences came in how the problem based approach was being implemented (Stigler & Hiebert, 2004). They found that countries who scored high in the TIMSS study, such as Japan and Hong Kong, exhibited classrooms in which the teachers taught mathematics using the problem based approach in a manner consistent with how they were designed to be used (Stigler & Hiebert, 2004). They found that countries that ranked low in the TIMSS study, reported using the problem solving approach, and did not use them in the manner in which they were designed to be used (Stigler & Hiebert, 2004). In the US, it was discovered that none of the teachers implemented the problem based approach in the way they were supposed to be used (Stigler & Hiebert, 2004). The researchers concluded that the US should focus on the "details of teaching, not teachers" (Stigler & Hiebert, 2004, p. 15). The work of Stigler and Hiebert illustrates the importance of effectively teaching mathematics.

In focusing on how to effectively teach mathematics, it is critical to examine how prospective math teachers are being taught to teach. In *Preparing Teachers to Learn From Teaching*, Hiebert et al. (2007) proposes a framework that could be used in educational programs to help accomplish the conclusion of the Stigler and Hiebert (2004) study. They proposed helping prospective teachers develop teaching skills by analyzing others that are teaching (Hiebert et al., 2007). The perspective teachers were to focus on "specifying the learning goals, conducting empirical observations, construct hypothesis about the effects of teaching on student learning, and use analysis to propose improvements in teaching" (Hiebert et al., 2007, p. 59). This study, just as the previous study, placed an emphasis on how to effectively teach. In the latter study, Hiebert et al., proposed accomplishing this feat by allowing prospective teachers to essentially judge other teachers through the four skills mentioned earlier (Hiebert et al., 2007). The analysis from the TIMSS study has shed light on a major flaw in the teaching practices of some US math educators. This major flaw is that many of those teachers do not teach the problem solving approach effectively or even at all (Stigler & Hiebert, 2004). In *Making*

Sense, Hiebert et al. (1997) acknowledges this flaw and recommends a solution to addressing it. To effectively teach using the problem based approach, Hiebert et al. suggests that teachers play a minimal role in helping the students come up with solutions to the given problem (Hiebert et al., 1997). Hiebert et al. goes on to elaborate by giving clear explicit examples of the correct way to teach using problem solving as well as the incorrect way to do so, in addition to explaining why the correct way was correct.

These studies illustrate how important it is to effectively teach mathematics and according to the first study, effective teaching was the main reason Japan and Hong Kong were high ranked in the TIMSS survey and the U.S. was ranked low.

When determining how students learn mathematics, it is important to consider how they are engaged in learning. Many ideas, theories, and practical techniques are available to those teaching mathematics. Mathematics education research has revealed that the teacher must foster a learning environment that entices students to actively engage in learning mathematics. Creating such a learning environment involves effective lecturing and utilizing inductive teaching techniques.

The topic of lectures and its use in getting student engaged in learning mathematics is much debated. A lot of educational reformers discourage lectures and argue more for collaborative and or inquiry learning (Hiebert et al., 1997). Those reformers have a variety of reasons for supporting their argument in that collaborative and inquiry learning allows the student to actively engage in learning mathematics (Hiebert et al., 1997). On the contrary, in *How to Teach Mathematics* (a book about effectively teaching college level mathematics), Krantz (1999) argues that if lectures are implemented correctly they can be effective in getting students engaged, and Krantz offers support for this position. Krantz (1999) argues that lectures have been used for over 3,000 years and they've been very effective. To further illustrate this point, Krantz (1999) discusses how effective many self-help infomercials or other similar unscientific schemes successfully get viewers to not only believe what they are selling, but to contribute financially to these schemes. The point that he made was that these individuals successfully do this by lecturing, not using collaborative or inquiry learning (Krantz, 1999). The key ingredient that makes late night shows (which is a form of lecturing), religious clergy sermons (another form of lecturing), effective in engaging their audience is that the speakers have a skill of handling people and communicating with their subjects (Krantz, 1999). As Krantz has illustrated, despite the growing trend to criticize lectures, they can be effective in engaging students in mathematics if they are used effectively.

How Students Learn Mathematics

Utilizing an inductive method to teaching mathematics has been shown to illicit an environment that fosters student engagement in learning the material. Krantz (1999) argued that students do not learn mathematics deductively but inductively. Krantz demonstrated this phenomenon by examining mixed partial derivatives. He started with primitive examples and allowed the students to see patterns and relationships; form there, he allowed the students to inductively come up with the concept of mixed partial derivatives (Krantz, 1999). He applied this phenomenon to another situation via Green's theorem (Krantz, 1999). In both cases Krantz argued that the students learn those Calculus concepts with understanding because they learned them inductively. Similarly, this use of the inductive method has been shown to foster student engagement in creating problem centered environments in a k-12 setting (Hiebert et al., 1997). Hiebert et al. (1997) argues that creating problem centered environments helped to engage students in mathematics. As an example of using the inductive method to engage students; Hiebert advocated giving students special problems to work out that will force them to think inductively. The teacher has minimal influence as the students used inductive reasoning to answer their questions, looking at patterns of previous problems and solutions to figure out inductively how to solve the present problem at hand (Hiebert et al., 1997). The works of Krantz and Hiebert demonstrated the inductive approach as an effective means of engaging students in learning mathematics.

In conclusion, engaging students in Mathematics is critical for not only effective teaching, but critical for getting students to understand mathematics as well. In getting students engaged, one must lecture effectively and use the inductive approach in presenting mathematical concepts. Because effective lecture and the inductive teaching approach encouraged student engagement, an instructor can design a classroom that enhances learning. A classroom utilizing these two ideas should prepare engaged students to learn mathematics for understanding.

Meaningful Learning Environments

One approach shown to increase students' mathematical understanding is to create a meaningful learning environment. Two critical characteristics of a meaningful learning environment are the teacher's pedagogical content knowledge and the supports for a learner centered instruction.

A teacher's pedagogical content knowledge has been shown to be associated with their students' meaningful learning (Reich, Murnane, & Willett, 2012). When mathematics education research is done on how technology is effectively used in teaching mathematics, most results show that the teacher's pedagogical content knowledge was a contributing factor in student achievement (Reich et al., 2012). Recently a study was conducted on the state of Wiki usage in American public schools (Reich et al., 2012). This study highlights the disparities between wiki usage in high and low income public schools, and in doing so it also characterized the lower income or disadvantaged students usage of computers as “tended to use computers for unsupervised drill and practice routines;” while those from advantaged backgrounds wiki use were characterized as “more likely to use technology for higher order thinking when there was more adult involvement.” (Reich et al., 2012, p. 8). The Reich et al. (2012) study illustrated that higher order skills were used with students from advantaged backgrounds. As shown in many other studies comparing academic achievement of students from various SES backgrounds, students from higher SES backgrounds outperform their lower SES peers (Reich et al., 2012). The Reich study implies one reason for this achievement gap maybe because those of higher SES backgrounds utilize higher order skills (Reich et al., 2012). Because of the use of higher order thinking skills, research also indicates (Reich et al., 2012) that those students are more likely to learn the material in a meaningful manner.

In order for a teacher to design classroom assignments that utilize these higher order thinking skills, the teacher's pedagogical content knowledge must be developed in such a manner that allows and encourages students to think at a deeper level. Bransford et al. (2000) confirmed the importance of the teacher’s pedagogical content knowledge in teaching for understanding “Outstanding teaching requires teachers to have a deep understanding of the subject matter and its structure, as well as an equally thorough understanding of the kinds of teaching activities that help students understand the subject matter in order to be capable of asking probing questions” (p. 188). Bransford et al. (2000) further highlight the critical nature of the teacher’s content pedagogical knowledge “expert teachers have a firm understanding of their respective disciplines, knowledge of the conceptual barriers that student face in learning about the discipline, and knowledge of effective strategies for working with students… The teachers focus on understanding rather than memorization and routine procedures to follow and they engage students…" (p. 188). In essence, a teacher with a deep understanding of the subject matter and the way in which students learn the content will be in a better position to teach students those higher order thinking skills that were so important in the Reich et al., (2012) study.

Learner centered instruction is another theme prevalent in mathematics education research. Most studies in this literature encourage the teacher to design lesson plans around the learner and center it on the learner and many studies suggest more emphasis on the student. In *Making Sense*, Hiebert et al. (1997) not only advocate focusing the lesson on the learner but he goes further in suggesting very little intervention by the teacher even when students are struggling

> ..she or he should allow the students to work on the task without continual interruptions and interference…teachers do not always realize the extent to which students can be trusted to resolve their own dilemmas while they are struggling with a problem…constructing mathematical knowledge and reaching true understanding are deeply personal processes which are very sensitive to interferences. (p. 125).

Hiebert et al. (1997) emphasized another theme discussed earlier that confirms the constructivist theory in which students construct meaning; however, it's clear from Hiebert et al. (1997) that doing so means that the lesson should be centered on the learner, with no interference from the teacher.

To successfully plan lessons focused on the learner, one must consider the needs and backgrounds of the individual learners. Making sure all learners have the same access to an education in which teaching for understanding is critical to learner centered instruction as well as a very important social concern. In the Reich et al. (2012) study it was shown that lower SES students do not receive instruction with higher order skills as their higher SES counterparts and quantitative research has shown those higher SES students generally do better with academics than the their lower SES counterparts. Most mathematics education research indicates this gap in part due to the fact that the students who utilize higher order skills are taught for understanding. Hiebert et al. (1997) highlighted the importance of ensuring all students get the same quality instruction when instruction is learner centered and the teacher considers the needs and backgrounds of the individual learner. Hiebert et al. (1997) indicated this in response to the idea that because a child is labeled as 'slow' doesn't mean they can learn math meaningfully, "we have seen children categorized as learning disabled - as well as those with much more sophisticated abilities - learn mathematics with understanding." (p. 66).

Learner centered instruction must consider the individual learner as Hiebert illustrates when responding to studies that indicated children of low SES, minority children, and girls get basic skill instruction while high SES students get teaching for understanding. "Learning with understanding by all children happens when teachers specifically attend to creating a classroom environment that takes into consideration the uniqueness of each individual and attends to critical dimensions of learning characteristics of individuals – not when teachers ignore the traditionally underachieving groups." (Hiebert et al., 1997 p. 66). The Hiebert et al. (1997) and Reich et al. (2012) studies implied that learner centered instruction should involve teaching for understanding with all students regardless of demographic background or even perceived mental ability (e.g. ‘slow’).

In conclusion, this research suggests that teachers need strong and flexible pedagogical content knowledge that guides a learner centered classroom in order to support learning for understanding. This literature also revealed that meaningful learning cannot occur without those two essential key elements. Without an appropriate level of pedagogical content knowledge a teacher will find a hard time explaining mathematics in depth to learners in a way that requires the students to use higher order thinking skills as opposed to them mastering basic skills. Strong pedagogical content knowledge is essential to developing lessons that utilize higher order thinking skills but are designed and implemented so that they are still within the reach of the learner’s knowledge level. Furthermore, if the instruction isn’t learner centered, the research implied that students were less likely to be engaged, they were less likely to learn meaningfully, and the teacher could perpetuate inequalities.

Gender

There are many studies that examine the math and science achievement differences between males and females. When it comes to science and mathematics women have traditionally and continue to be underrepresented in these fields (Hyde & Linn, 2006). Many researchers have studied this area in great detail in order to reveal possible reasons why this deficit in achievement and representation exists with males and females. Most of the gender studies that focus on math and science revealed when students are in the early years, there is little difference between achievement in males and females, but in higher grades the deficit gets much larger (Hyde & Linn, 2006). Researchers in the middle to late nineties performed gender research studies in math and science to understand possible factors for the achievement differences seen in high school and college. Most of these research studies revealed psychological differences as possible factors for the math and science achievement gap (Casey, Nuttall, & Pezaris, 1997; Catsambis, 1994; Frost, Hyde, & Fennema, 1994; Seegers & Boekaerts, 1996; Stage & Klossterman, 1995; Udo, Ramsey, & Mallow, 2004). Other studies indicated differences in approach to mathematics or the type of mathematics considered (Carr & Jessup, 1997; Gallagher & De Lisi, 1994; Mau & Lynn, 2000).

Differences in Achievement with males and females

In terms of achievement differences in math and science as it relates to males and females, the research is conflicted. As mentioned earlier, several studies show differences in achievement with males and females in mathematics and science, while other studies show no differences.

When examining science there appears to be a gap in achievement favoring males (Hyde & Linn, 2006). Hyde and Linn (2006) reviewed the various metaanalysis on achievement in math and science in grades k-twelve using research and data from various assessment instruments. Their metaanalysis review revealed, using data from the 2005 NAEP, that boys surpassed the girls in science up to the twelfth grade (Hyde & Linn, 2006). Interestingly, Hyde and Linn indicate a small difference in favor of females on computational mathematics in elementary and middle school, but no difference in high school (Hyde & Linn, 2006). The researchers also found that when it comes to solving complex mathematics problems boys surpassed girls at the high school level, but no difference in elementary and middle school (Hyde & Linn, 2006). Mau and Lynn (2000) also noted differences in achievement favoring males. These researchers focused on twelfth graders and examined data from the American National Educational

Longitudinal study (Mau & Lynn, 2000). Their analysis revealed that males did significantly better in math and science than females (Mau & Lynn, 2000). Frost et al. (1994) did a metaanalysis on 100 studies related to math performance and attitudes; in terms of achievement, their results revealed that males did slightly better than females. When examining the top level college preparatory students, it was similarly found that males have the advantage (Casey et al., 1997). Casey et al. (1997) examined the scores of the top third of college preparatory students taking the mathematics portion of the SAT. The analysis revealed that males showed an advantage in scores over the females, even though the researchers concluded there were no direct relationships for this difference (Casey et al., 1997). Finally, Catsambis (1994) did a study in which eighth graders were surveyed then surveyed again in the tenth grade. Their results indicated that males and females scored about the same in grades and test scores (Catsambis, 1994).

In conclusion, the literature indicates that some studies show differences in achievement in males and females. Most of these studies indicate a difference in achievement favoring males in the higher grades, while there is very little difference in elementary school. Some studies show males outperform females and other studies indicate the opposite, while others indicate no statistically significant difference in achievement based on gender. The next two sections will analyze possible factors that contribute to the differences in achievement.

Psychological factors contributing to achievement differences

The present section will examine the possible psychological factors that researchers have found that may contribute to the differences in achievement between males and females in math and science. Although, many psychological factors exists, the literature indicates that most are related to gender psychological differences, such as confidence in science or mathematics, attitudes regarding science and mathematics, beliefs about science and mathematics, interest in science and mathematics, as well as science anxiety. The research studies presented hereafter will illustrate how these factors were shown in studies to differ between males and females.

Confidence has been shown to play a role in achievement (Casey et al., 1997; Stage & Kloosterman, 1995). Stage and Kloosterman (1995) examined remedial mathematics collegiate students to investigate what predictors were strongest for males and females using their final grades as the dependent variable. The researchers concluded that the biggest predictors for females were beliefs and pretest scores; while for males, pretest scores, math assessment scores, and high school math exposure were the biggest predictors for final grades. In essence, the Stage and Kloosterman (1995) results support the notion that confidence correlates to the females' final grade in a remedial mathematics, while confidence does not have the same correlation with males (Stage & Kloosterman, 1995). Catsambis (1994) also concludes that females expressed less confidence in their ability to do mathematics. In the Casey et al. (1997) study mentioned earlier, the researchers concluded that the boys had an indirect effect of more confidence (compared to the girls) that was a factor in their advantage in SAT math scores (Casey et al., 1997). Essentially, the Casey et al. (1997) study revealed that the advantage the males have on the SAT math section is due partly to the indirect effect of confidence.

In terms of attitudes, the literature indicates that females and males differ on attitudes towards math and science (Frost et al., 1994). The Frost et al. (1994) study mentioned earlier also revealed that females had more negative attitudes than the males in regards to mathematics. Another study limited to 186 eight graders revealed that girls have less self efficacy when doing mathematics than boys (Seegers & Boekaerts, 1996). Both the Frost et al. (1994) and Seegers and Boekaerts (1996) studies demonstrated that females tend to have more negative attitudes in their ability to do mathematics than males. A similar trend follows for the remaining psychological factors.

Researchers examining beliefs, interest, and anxiety revealed a similar pattern as confidence and attitudes. The Seegers and Boekaerts (1996) also concluded "as a group, girls have less favorable beliefs about their mathematical ability." (Seeger & Boekaerts, 1996, p. 236). When examining interest, the Catsambis (1994) study also reported that females expressed less interest in doing mathematics. In terms of science anxiety, the findings follow a similar pattern as the other psychological factors. Udo et al. (2004) did a research study with non science majors taking general education science college classes. The researchers found that one of the leading predictors of science anxiety was gender (Udo et al., 2004). Their findings revealed that females tend to have more science anxiety than males (Udo et al., 2004).

In conclusion, the research demonstrated that there are differences between males and females psychologically in their approach to mathematics and science. The studies revealed that beliefs, confidence, attitudes, and interest are different for males and females when they approach mathematics. The next section will examine the differences in technique and the type of mathematics.

Differences due to technique and type of mathematics

In addition to the literature demonstrating differences in gender due to psychological factors, the research also indicated differences in achievement due to other factors such as technique and the types of mathematical problems under consideration (Carr & Jessup, 1997; Gallagher & De Lisi, 1994; Mau & Lynn, 2000).

Gallagher and De Lisi (1994) illustrate how the differences in techniques between males and females can lead to different results seen in the types of mathematical problems solved. Gallagher and Lisi did a research study on the SAT mathematics scores of students scoring 670 or higher. They found that the females tended to use conventional mathematics techniques to answer problems, while males tended to use non-conventional strategies to answer problems (Gallagher & De Lisi, 1994). Further analysis revealed that females did better with conventional problems and males did better with unconventional problems (Gallagher & De Lisi, 1994). The same difference in how males and females approach mathematics is seen as early as first grade (Carr & Jessup, 1997). Carr and Jessup (1997) allowed first graders to work in groups while they worked on addition and subtraction problems. The results of this study revealed that even in first grade the girls and boys used different strategies to solve the mathematics problems (Carr & Jessup, 1997). They found that the girls preferred method was by counting their fingers or using counters, while the boys preferred method was solving the problems by memory (Carr & Jessup, 1997). The two studies indicate that by the nature of being different, males and females tend to have different approaches to solving problems. This difference may explain one of the results from the Mau and Lynn (2000) study. The Mau and Lynn (2000) study also revealed that although males did better in math and science, females' reading scores were higher than males'.

In conclusion, the research illustrates that males and females tend to approach (psychological or non-psychological) mathematics differently. The studies in this section revealed that these are possible factors for the achievement differences seen with males and females.

Age and Enrollment Status

Research in science and mathematics education indicates that many factors influence achievement. In a community college setting, many students are nontraditional. Nontraditional students tend to have families, jobs, and are typically over 25 years of age (referred to as 'older students'). Regardless of age, many students have different enrollment statuses and research has shown this makes a difference in achievement (Fike & Fike, 2008; Horn & Ethington, 2002; Penny, White, & William, 1998). This section will examine research done on relationships or effects, age and enrollment, have on achievement.

Age

In terms of age, several studies demonstrated that age has an effect on achievement (Buchanan, 2006; Calcagno, Crosta, Bailey, & Jenkins, 2007b; Johnson, 1996; Kasworm & Pike, 1994) . When examining achievement, the research has shown that the influence of age has yielded interesting results on graduation and remedial classes (Calcagno et al., 2007b). Calcagno et al., (2007b) did a study comparing the achievement of older students (over 25 years old) and younger students (25 years and younger) at community colleges in Florida. The researchers found that finishing 20 credits or half of an entire program was more important to predicting the graduation for younger students than the older students (Calcagno et al., 2007b). The same study also revealed that in terms of graduating, older students were less negatively impacted by remedial classes as the younger students (Calcagno et al., 2007b). Another related study by the same researchers examining community colleges in Florida revealed that the older students were more likely to finish a degree or certificate than the younger students (Calcagno et al., 2007a).

Another aspect of achievement critical to considering possible relationships to age is grade point average. Studies revealed there is a relationship between age and grade point average (Buchanan, 2006; Kasworm & Pike, 1994). Buchanan (2006) researched this very relationship in the Los Angeles Community College District. Over 5,000 students were surveyed and the focus of this study was on math and science (Buchanan, 2006). The Buchanan (2006) findings revealed there was a significant relationship between age and GPA. Although, there is not much recent literature on this topic, most of the research generally revealed that this relationship favors older students (Kasworm & Pike, 1994). Even though older students come to school with several disadvantages they still outperform the younger students in college grade point average (Kasworm & Pike, 1994). Kasworm and Pike (1994) examined students at the undergraduate level. This study, like the former, compared the college grade point average of the older students and the younger students (Kasworm & Pike, 1994). Their findings revealed that even though older students had lower high school grade point averages, lower ACT scores, more likely to be married, and more likely to be part time students, they still had a significantly higher college grade point average than the younger students (Kasworm & Pike, 1994). In Johnson (1996), a similar result was found. Johnson examined college students in entry-level mathematics and the results revealed that age had a positive correlation to mathematics success.

In conclusion, research revealed that the age of a student may have an impact on the likelihood of graduation or their accumulative college grade point average. The research further revealed that older students tended to outperform the younger students in terms of achievement, even though they had several disadvantages when they started college (Kasworm & Pike, 1994).

Enrollment

In addition to the age of a student, the enrollment status of a student has also been shown to have an impact on academic achievement. The following research studies confirm that the enrollment status of the student does impact achievement (Fike & Fike, 2008; Horn & Ethington, 2002; Penny et al., 1998).

In terms of mathematics achievement for undergraduate students, research indicates that enrollment status is a predictor (Penny et al., 1998). Penny et al. (1998) conducted a study with data collected from Mississippi State University, University of New Orleans, and Southern University. The findings of this study revealed that for students in college algebra and developmental mathematics enrollment status was among one of five predictors of academic achievement (Penny et al., 1998).

When specifically examining academic achievement in terms of retention at community colleges, the research indicates that enrollment status was a predictor (Fike & Fike, 2008). Fike and Fike (2008) analyzed data from 9,200 first time community college students. These researchers were examining predictors for retention rate (Fike & Fike, 2008). The results of this study revealed that the number of hours enrolled was a predictor (Fike & Fike, 2008).

When examining beliefs that students have about academic achievement, enrollment is a shown to have an influence (Horn & Ethington, 2002). Horn and Ethington (2002) measured achievement in terms of beliefs. Horn and Ethington did a study that involved measuring beliefs about academic growth and development that the students reported. This study was done at a community college with students desiring to transfer to a four year institution (Horn & Ethington, 2002). The researchers found "significant main effects were found in differences...between full-time and part-time students" (Horn & Ethington, 2002, p. 401).

As the previous studies indicate that enrollment status has an influence on achievement and beliefs; there appears to be a contrast in regards to measuring attitudes. Grimes and David (1999) analyzed data from a Florida community college with 8,000 students and found there were no significant differences between the full-time and part-time students in terms of attitudes (Grimes & David, 1999).

The research presented in this literature review indicates that the enrollment status of a student was likely to have an impact on their achievement. As other factors have been researched and shown to have an influence on academic achievement, research revealed that the enrollment status of a student had an influence as well.

Previous Mathematics Background

It is well known that many students enrolling in community colleges have to take remedial math courses before enrolling in college algebra. Usually students who take these courses have to do so because of their previous mathematics background. Some students may not have the minimum ACT/SAT math test score, high school mathematics grade point average, or other similar factors that community colleges require to enroll in college algebra. As of late, the number of students having to take these remedial courses is of interest. Some studies have revealed the number of students needing to take remedial courses is well over the majority of the college student body, 55% in one study (Sanders, 2004). Even advanced math based majors have issues with science achievement based on their mathematics background (Becker & Towns, 2012). This was revealed with students taking physical chemistry (Becker & Towns, 2012). This section examines the research on previous mathematics background and any effect or relationship it may have with math and science achievement.

One of the leading trends in analyzing the students' previous math background is that the previous math habits or grades seemed to follow the student into their successive math classes (Gonzales, 2012; Johnson, 1996). Johnson (1996) addressed the issue of the bad grades or habits following the student into their next math class. The Johnson (1996) study revealed that gaps in the developmental math course sequence negatively correlates with entry-level mathematics. The same study also revealed that when students did well in developmental math classes, they were likely to do well in entry-level mathematics (Johnson, 1996). The Johnson study also revealed that students who performed poorly in developmental mathematics did so in entry-level mathematics. The negative association between the gap in developmental math courses and the achievement thereof revealed in Johnson was elaborated on in Gonzales (2012). Using six years of data, Gonzales focused on the achievement in college algebra based on previous mathematics background. This study revealed "that each gap within developmental mathematics courses increases the risk of failure by 1.5 times." (Gonzales, 2012, p. IV).

The research also revealed that the type of previous math courses taken had an impact on the present math class (Fong, Huang, & Goel, 2008; Laurent, 2009; Tauer, 2002). In students who were taking math classes as advanced as calculus, it has been shown that the previous math class had an impact (Laurent, 2009). Laurent (2009) was conducted at a Missouri College and it analyzed this very topic with students who took Calculus in college. In this study, it was revealed that those who took an AP calculus in high school did significantly better in calculus than those students who were dual enrollment students (Laurent, 2009). This same study highlighted just how important having taken AP calculus was. The researcher also found that there was no statistically significant difference between dual enrollment students and students who had no college credit prior to taking this college calculus course (Laurent, 2009).

Not only has the previous math courses been associated with performance as revealed in Laurent, but it has also been shown to predict whether a student will take remedial math classes (Fong et al., 2008). The Fong et al. (2008) study took place in Nevada and analyzed the math courses taken in high school. The Fong et al. study focused on whether a student's previous math classes would predict if the student took remedial math courses in college. This study revealed that the probability of a student taking math remedial classes in college is 2.5 times higher if they only finished middle II mathematics classes than students who took more advance math classes in high school (Fong et al., 2008).

Not only is this phenomena present in college mathematics, but it is also seen in high school mathematics (Tauer, 2002). The Tauer (2002) study focused on high school students in Witchita, Kansas. This study contrasted mathematics achievement between two different mathematics curricula (Tauer, 2002). It was revealed that the mathematics curriculum taken made a difference on achievement (Tauer, 2002). For this study it was found that the core-plus math yielded better results than the traditional mathematics course (Tauer, 2002). Interestingly, one of the measures of success was the number of students who took senior level mathematics classes (Tauer, 2002). However, even though this study was done in a high school setting, the researcher came to the same conclusion revealed in the Fong et al. (2008) study (Tauer, 2002). In discussing the importance that the impact previous math background had on achievement, Tauer (2002) acknowledged this phenomena by stating "it is well documented that enrollment in senior mathematics courses is highly correlated with success in the first college mathematics course." (Tauer, 2002, p. 5).

In conclusion, the research studies in this section revealed that a student's previous mathematical background had an impact on the math class they were presently taking (Fong et al., 2008; Gonzales, 2012; Johnson, 1996; Laurent, 2009; Tauer, 2002). Studies have shown the class taken can be a predictor of success as well as a predictor of failure (Johnson, 1996; Tauer, 2002). Therefore, when considering possible predictors for achievement in the present math course, previous mathematics background should be considered.

Homework/Study Time

When examining the various factors that impact achievement in Mathematics, it is important to consider the amount of time the student spends outside of class doing mathematics. The remainder of this section will examine the research on how homework and or study time impacts mathematics achievement.

Although the present literature lacks sufficient studies that examine the impact of homework in collegiate mathematics courses there are quite a few studies that consider this phenomenon in kindergarten through twelfth grade. Betts (1997) used data from the Longitudinal Study of American Youth and found a positive correlation between math achievement and the amount of homework assigned (Betts, 1997). More startling, is one of the following conclusions from this study "An extra half-hour of nightly homework between grades 7-11 is predicted to boost math achievement by almost 2 grade equivalents" (Betts, 1997, p. 96). The Cooper, Robinson, and Patall (2006) study involved a synthesis research study on homework achievement, analyzing data from 1987 to 2003. These researchers reached the same conclusion as Betts (1997). They concluded that homework has a positive influence on achievement and that this is seen more in grades 7-12 than K-6 (Cooper et al., 2006). Not only did the research studies reveal this positive correlation, but one study found that homework had the most impact on achievement (Singh, Granville, & Dika, 2002). Singh et al. (2002) examined data from the National Education Longitudinal Study of 1988 and found that of all the possible predictors studied, time spent doing homework had the strongest impact (Singh et al., 2002). Other studies have revealed that not only is the time spent doing homework a significant contribution to mathematics achievement but doing other things such as watching TV can actually have a negative impact on achievement (Aksoy & Link, 2000). Askoy and Link (2000) examined data from the National Educational Longitudinal Studies program and found that "extra time spent on mathematics homework increases student test scores, while extra hours per day watching television negatively impacts math test scores" (p. 261).

When examining the issue of homework and its impact on achievement it is important to consider the difference between the teacher assigning homework and the students actually doing the homework. One study examined this very issue and revealed the results both have on achievement (Cooper, Lindsay, Nye, & Greathouse, 1998). Cooper et al., (1998) revealed the same conclusions as those found in the previous studies. Cooper et al. (1998) found that there is not a strong correlation between homework assigned and the achievement, but there is a positive strong relationship between the homework completed and achievement.

Even though most studies indicate a positive relationship between homework and achievement, there are a few studies that find homework does not have such an impact on achievement (Trautwein & Koller, 2003). Trautwein and Koller (2003) involved a comprehensive review of the twentieth century homework studies and found that the relationship between time spent on homework and achievement was very weak, so weak that these researchers concluded that this relationship is unclear (Trautwein & Koller, 2003). Because of this unclear relationship, more research needs to be done on the effect or the lack thereof that homework has on achievement.

On the collegiate level, there were only two studies found that relate to this issue; however, from these studies the relationship is also unclear. Gramlich (2012) examined math students at a northwest community college. The researcher was looking for predictors of community college mathematics achievement (Gramlich, 2012). In terms of homework or study time, the data from Gramlich revealed that students spent more time on the job than doing homework. As a result of this revelation, the researcher concludes that students need to spend more time doing homework (Gramlich, 2012). Although the conclusion could be implied from the previous K-12 studies, it is unclear the type or level of impact homework has on achievement in collegiate level mathematics.

Although that relationship between homework and achievement is still somewhat unclear in collegiate mathematics, there is a study that examines the study behavior of students at the collegiate level (Hagedorn et al., 1999). Hagedorn et al. (1999) analyzed data from first year college students taking remedial and non remedial math courses. The researchers found that not only did remedial students have a lower mean study time, but remedial students also reported studying less in high school as well as having lower high school grade point averages than their non-remedial peers (Hagedorn et al., 1999). It was apparent from this study that the habits these students had in their previous math background carried over to the present math course. The phenomenon was also revealed in the studies mentioned in the previous math background section of this literature review.

In conclusion, although there are a few dissenters such as Trautwein and Koller (2003), the majority of researchers were in agreement that the amount of time doing homework or studying had a positive impact on achievement in mathematics (Aksoy & Link, 2000; Betts, 1997; Cooper et al., 1998; Cooper et al., 2006; Singh et al., 2002). Not only did homework have a positive impact, but in some cases time spent on homework was the biggest factor in mathematics achievement (Singh et al., 2002). Although there was little research on this connection on the collegiate level, it is clear that in kindergarten through twelfth grade it was a common phenomenon.

Homework Method

Lately, more and more educational institutions have implemented online homework as a means for assessing students learning in science and mathematics. Studies (Allain & Williams, 2006; Ashby, Sandera, & McNary, 2011; Bonham, Deardorff, & Beichner, 2003; Cole & Todd, 2003; Demirci, 2010; Gok, 2011; Heid & Blume, 2008; Hirsch & Weibel, 2003; Johnston 2004; Kaput & Thomspon, 1994; Kieran & Guzman, 2005; Krantz, 1999; Macedo-Rouet, Ney, Charles, & Lallich-Boidin, 2009; Masalski & Elliot, 2005; Mendicino, Razzaq, & Heffernan, 2009; Zerr, 2007; Zhang & Jiao, 2011) are conflicted in regards to the achievement gained when students do homework the traditional method or online. This portion of the literature review analyzed the research on technology and learning. After that, the researcher presented an analysis of statistical results from research studies comparing the achievement to the homework method.

Technology and Education

Studies in Mathematics research indicate that in teaching for understanding, it is important to consider the cognitive implications technology and visual representations have on the students. Many studies indicated that there are positive benefits to implementing technology in Mathematics education; however, there were still studies that show the harm and danger associated with implementing technology in Mathematics education (Masalski & Elliot, 2005). In addition to technology having a cognitive impact on students' learning, visual representations have been shown to have an effect as well (Hiebert et al., 1997).

Research has shown that technology can have a cognitive impact on learning Mathematics. For example, it has been shown that allowing the use of technology to substitute basic arithmetic algorithms allows students to focus on understanding deeper, more abstract, and less routine mathematics (Masalski & Elliot, 2005). In a study by Kieran and Guzman entitled *Five Steps to Zero: Students Developing Elementary Number Theory Concepts When using Calculators* it was found that students can enhance their mathematical understanding of factoring by using calculators (Masalski & Elliot, 2005). In this study, the researchers wanted students to gain a new mathematical understanding of factoring by giving them a large number and having them factor it by using the calculator as far as they could using the fewest number of steps (Masalski & Elliot, 2005). One of the conclusions from this study was that by using the calculator, the students did not have to worry about computational arithmetic procedures and could instead focus on developing their understanding of factoring (Masalski & Elliot, 2005).

Research has shown that technology can have a cognitive impact in learning mathematics by promoting students intuitions (Masalski & Elliot, 2005). In a study done by Knuth and Hartmann it was found that technology enhanced the students' intuition of graphing systems of equations (Masalski & Elliot, 2005). The researchers posed a real life problem involving two phone plans that could be represented as a system of two linear equations and the students were to find which plan over time was cheaper (Masalski & Elliot, 2005). Instead of having the students solve it algebraically and find where the solution exists, they used technology to graph the two plans as two lines where they would examine the point of intersection and discuss the practical information gained from this graph to determine which plan was cheaper over time (Masalski & Elliot, 2005). In discussing the results seen on the graph, the students were forced to examine their intuitions about systems of linear equations and the practical application thereof. As seen in the Kieran and Guzman (2005) study, the use of technology allowed these students to focus on developing their basic understanding and intuition of systems of linear equations (Masalski & Elliot, 2005). Because these students did not have to focus so much attention on basic computational algorithmic techniques such as graphing the two lines by hand and scaling a graph, the students were in a better position to focus on the implications and practical knowledge gained from the graph they made using technology.

Research has also shown that visual representations can have a positive cognitive impact on students learning. In a study done by Fusion (1997) as cited in Hiebert (1997), K-3 grade level students were given projects designed for the purpose of allowing students to develop deeper cognitive meanings for arithmetic operations in base 10 (Hiebert et al., 1997). In this study, the students used visual representations of addition and subtraction from classroom vignettes to express various arithmetic operations in base 10 based on real world math problems (Hiebert et al., 1997). The results of this study revealed that the students' diagrams of adding and subtracting the numbers based on the vignette illustrated their fundamental thinking and understanding of operations in base 10 (Hiebert et al., 1997). Another study illustrated the positive impact on students' mathematical understanding involves using virtual manipulatives. This study was done by Moyer, Niezgoda and Stanley (2005) and the subjects of this study were young children in the process of learning to count. For this research design, students used the computer to utilize virtual manipulatives in the form of base 10 blocks to add various numbers (Masalski & Elliot, 2005). The students had to write and show, using these virtual manipulatives, the process they used to arrive at their answer (Masalski & Elliot, 2005). From analyzing the students' work the researchers concluded that virtual manipulatives were used to "make important connections among... abstract mathematical ideas and the processes underlying these concepts" (Masalski & Elliot, 2005, p. 33). Although, this study used visual representations to improve the mathematical cognitive skills of the young children; the students understanding of addition was further promoted by the use of technology. As shown in the previous studies; using technology simplifies remedial tasks (in this case, physically arranging and picking up actual blocks) allowing students to focus on more of the abstract elements of mathematics.

In conclusion, these studies implied that technology and visual representations assisted the students in developing their cognitive mathematical skills. Implementing technology eliminated the need for a lot of remedial tasks that may have inhibited the students' concentration on bigger abstract mathematical ideas. Visual representations allowed students to develop a greater intuition of various mathematical ideas when they are allowed to see aspects of the topic for a different non algebraic and graphical perspective. The combination of visual representations and implementation of technology may further promote the learner's comprehension of abstract mathematical ideas when used appropriately.

Many researchers felt that math educators should not continue to teach mathematics with the current Mathematics curriculum using many of the same methods employed in the late 1800's (Jacobs, 2009). In *Curriculum 21*, Jacobs (2009) argued that the current mathematics curriculum needs to be changed to reflect a more global 21^{st} century reality. She argued that many of the current techniques being used are antiquated for a 21^{st} century global environment (Jacobs, 2009). Throughout the course of educational reform, many changes have occurred in Mathematics Education (e.g. the *Progressive Er*a and *New Math Era* to name a few).

In the past, Mathematics Education Researchers have used similar arguments for changing the Mathematics curriculum with NCTM creating the *Math Standards* era. In Curriculum 21 many of those arguments are used to advocate change in the curriculum; however, some of the most important changes advocated by Jacobs includes developing a pool of assessment replacements, replacing dated assessments with modern ones, sharing assessment upgrades with others, and creating ongoing opportunities for upgrading assessments (Jacobs, 2009).

In a discussion of the effects of these changes; Jacobs also implied a fundamental constructivist approach to changing the Curriculum, a theme that was prevalent in Making Sense (Hiebert et al., 1997). In a discussion of implementing the above changes in science and mathematics, Jacobs stressed the importance of not using recipe science labs, but developing labs that allowed students to solve problems and discover science (Jacobs, 2009). Hiebert et al. (1997) advocated this very same problem based approach as a means of teaching mathematics with understanding. As common in most of the recent Mathematical education reform ideas, Jacobs and Hiebert both argued for changing the Mathematics curriculum in a manner that had constructivist ideas implanted in the core.

Another common theme seen in most Mathematics Educational Reforms is the need to integrate more technology into the Mathematics curriculum. Jacobs (2009) argued this very point when she supported the idea of having students develop *digital portfolios*. The argument developed by Jacobs for using *digital portfolios* stemmed from many others commonly used to advocate for technology in the classroom. These ideas include technology being more relevant to students today than in the past and that technology was a must for the student to compete with their peers on a global level (Jacobs, 2009). There were many research studies that revealed gains in understanding when utilizing technology in mathematics. In *Research Synthesis*, there was a study that revealed positive results from integrating technology into the mathematics curriculum (Heid & Blume, 2008). This study was done at the University of Georgia in which 3rd graders learned fractions on the computer and resulted in "significant gains in the area of proportional reasoning" (Heid & Blume, 2008 p. 40). As promising as these studies seemed, there were many scholars that warned educators to show caution when integrating technology in the classroom. In reference to college level Mathematics, Krantz (1999) cautioned against abandoning lectures (that have been used for over 300 years) in favor of technology (which clearly has not produced the same 300 year track record). As seen in the previous works of literature, the need for integrating technology in mathematics remains a central focus in Math education reform.

In conclusion, many researchers have seen the need to reform the current Mathematics curriculum to reflect a more current twenty first century global approach.

Two of the common recurring ideas behind these reforms included utilizing technology and having the constructivist approach as a fundamental tenant to the core of such reforms.

It should be noted that the research also shows that a teacher's pedagogical content is critical when utilizing technology (Kaput & Thompson, 1994). A study done by Kaput and Thompson (1994) analyzed the mathematics education literature and found early technology was poorly developed and designed to substitute the teacher instead of being utilized to assist the teacher with teaching higher order skills. The Kaput and Thompson (1994) study implied that a teacher's pedagogical content was essential to teaching meaningfully using technology "to use technology in mathematics education research is intellectually demanding – one must continually rethink pedagogical and curricular motives and contexts…" (p. 681). The study went further to emphasize this concept involving the teacher's pedagogical content knowledge being required even when designing the technology itself "only recently have calculator manufactures sought the advice of educators in the design of their products. And only recently have computer-based tools been specifically designed for learners." (Kaput & Thompson, 1994, p. 682). As the Kaput study revealed, using technology in math education can be intellectually demanding, but as shown with this study and the previous Reich study, a teacher's pedagogical content knowledge was absolutely essential in effectively using technology in a manner that will allowed the students to learn meaningfully.

Homework Method

Before commencing on the differences in student achievement with online homework versus paper and pencil based homework, the researcher briefly examined one social economic explanation of whether homework (in any form) is effective or not. For many years it was thought that homework was a good predictor of student success. More specifically, it was thought that students who did homework were more likely to succeed in class than those that did not do homework. For a time there was a debate on the effectiveness of homework itself; however, many studies have shown homework to be very effective and negligible in student success. A recent study by Ronning (2011) examined the issue of homework assignments and if they were beneficial to students. The study was done with students in elementary school from a variety of social economic backgrounds in the Netherlands (Ronning, 2011). The Ronning study found

> the test score gap is larger in classes where everybody gets homework than in classes where nobody gets homework. More precisely pupils belonging to the upper part of the socioeconomic scale perform better when homework is given, where pupils form the lowest part are unaffected. At the same time more disadvantaged children get less help from their parents with their homework. Homework can therefore amplify existing inequalities through complementarities with home inputs. (p. 55)

Perhaps the last two statements were why some of the studies showed that homework had a negligible effect; however, the Ronning (2011) study indicates that they are behind their peers in the higher SES levels that do homework. This study revealed that, at least in elementary school, parental involvement had a significant effect on student achievement and the best combination is parental involvement and homework. At this point, in the interest of increasing student achievement at any level, it is clear from the research that homework was important. It is critical to examine the method of homework that will further maximize student performance in class, web based or traditional paper and pencil based.

Recently, there is a growing push for teachers, instructors, and professors to utilize web based homework systems. The online homework is graded by the computer software for the teacher and students can get instant feedback when doing the online homework. However, some of the research revealed that there are disadvantages of using web based homework systems. In a study examining how web based homework influences the students ability to solve quantitative Physics problems in a calculus-based class, it was shown that web based homework had a dangerous negative impact on the students cognitive abilities to do Physics problems (Pascarella, 2004). In this study Pascarella (2004) compared students who did their Physics problems online with students who used the traditional pen and paper based methods. In her study, she found that the students who used the paper and pencil method worked out their problems like a PhD physicist would work out their problems and the students who used the web to do their homework problems did their problems using more of a guess-like novice approach (Pascarella, 2004). This study went further and switched the groups and they found the students who had switched over to the paper based method began to solve problems using the same method involving critical thinking skills as those students who initially used the paper and pencil method (Pascarella, 2004). The same thing happened when the traditional students went to the online version, they began to take the approach of a novice guesser in solving problems in fact one student remarked “I like the written homework because it's, just uh, much more self-explained, um and you can see exactly how and why the problem is done that way” (Pascarella, 2004, p. 4). The researcher in this study has shown qualitatively one of the negative implications of having students do homework online, they developed problem solving skills that are those of a novice and the students who did them the traditional way developed and utilized the same critical thinking skills of a professional. In terms of analyzing the research from a quantitative perspective it is not entirely clear if the there is an advantage in online versus the paper and pencil method of doing homework. Results from the literature show that there is not clear consensus on this issue. Researchers have found that there is no statistically significant difference in achievement between students who do homework the traditional method versus doing homework online. Other studies have shown that there were statistically significant differences in achievement in favor of students who did homework using the paper and pencil based method, and there were studies that show there was a statistically significant difference in achievement favoring those students who did homework online. The following studies below will further elucidate this point.

There are numerous studies that show there were no major differences in achievement between the online homework method and the traditional paper and pencil method. Johnston (2004) did a study that compared students doing their homework online versus those students who did their homework using paper and pencil; he found "that the actual homework performance of students was comparable, regardless of the method used" (p. 1). In a similar study done in Turkey by Demirci (2010), it was revealed that "there was not any significant difference in standardized test score results" (p. 1). This study also revealed that the only thing that yielded a statistically significant difference was the homework performance of both groups. Even with the homework, the Demirici study found that the pen and paper group did better on the homework than the web-based group; however, the next semester the web-based group scored significantly higher than the paper and pencil group. In this study it was shown that the only thing that yielded a significant difference was homework but that was offset by the fact that for the given year they were still the same (Demirci, 2010). Another study conducted by Allain and Williams (2006) yielded similar results to that of Johnston (2004) and Demirici (2010). This study was done with an introductory Astronomy class, and students were allowed to do homework online, using web assign, or do the traditional paper and pencil homework (that was not graded) (Allain & Williams, 2006). Again the test results, showed there was no statistically significant difference in the tests, final exam, and the normalized gain between both groups (Allain & Williams, 2006). Another study doing the same thing in an introductory chemistry class resulted in similar findings (Cole & Todd, 2003). Cole and Todd (2003) found that in an introductory chemistry class "there was no measurable quantitative effect on students' outcomes" (p. 1). Finally, in a study done by Bonham et al. (2003) the researchers looked at Physics classes (both algebra based and Calculus-based) and found no statistically significant difference in achievement between those that did their homework online versus those students who did their homework using the traditional pencil and paper method.

As stated previously there are studies that show that there is a statistically significant difference in achievement in favor of the traditional paper and pencil method. In a study by Zerr (2007) examining how effective online homework was in a first semester calculus course, their results were somewhat interesting. The findings show that for quiz and exam scores, the means for both the online and traditional groups were the same; however, students with previous college experience did worse on online homework than those with previous college experience that worked using the traditional method

(Zerr, 2007). Something else that was interesting was the fact that those students who did worse had a higher mean math ACT score (Zerr, 2007). In another study by Demirci (2007) in using introductory Physics students it was shown that the mean difference in FCI (Force Concept Inventory) scores was the same for both groups, however the paper and pencil group did statistically significantly better on homework than the online group (Demirci, 2007). In terms of other assessment mediums, in a study done in France, it was shown that in taking quizzes the students who had the paper based version of the quizzes did statistically significantly better than those students who took it online (even though the questions were the same) (Macedo-Rouet et al., 2009). Another study by Demirci (2006), this time using a general physics course instead of an introductory physics course, again it was found that there was only a statistically significant difference in homework favoring the paper and pencil group. All of the studies mentioned here show some difference in achievement in favor of students using the pencil and paper method.

Just as there are studies that favor the traditional method there were also studies that favor online methods. The first study involved comparing traditional and online groups in an introductory Physics class in the United States (Gok, 2011). In this study it was found that there were no significant differences on the exams but that the online groups performed significantly better on the homework (Gok, 2011). The next study examines the success of the two groups based on gains. The first study involves fifth graders doing their homework and shows a significant increase in gain for the students using the computer (Mendicino et al., 2009). Finally, the last study favoring the online homework method involves a study in a general calculus course in which the findings revealed a 4% statistically significant difference favoring the online students on the final exam (Hirsh & Weibel, 2003).

In terms of mathematics achievement in other factors related to the online or traditional method, the research revealed varied results. The Zhang and Jiao (2011) study concluded that the homework method was more or less effective depending on the topic. For example, the findings from this study indicated that the traditional method was best for algebra related topics and the online/computer method was best for topics related to graphing (Zhang & Jiao, 2011). The researchers also point out something that most studies neglected and that is the consideration of high or low achieving students and the method that works best for them. Zhang and Jiao concluded that low and average students gained the most from a hybrid format, while the high achievers gained the most from the traditional method.

While the previous studies examined achievement based on homework method in math and science classes, none of the former studies addressed developmental math classes at the community college. The only study that examined developmental math students at community colleges involves a study done at a mid-atlantic community college (Ashby et al., 2011). In this study it was found that the traditional method students performed better than the hybrid and online students (Ashby et al., 2011).

From the literature present, it was clear that there was no clear consensus as to which method of doing homework is better for student performance, online or traditional. There were studies that show the online method yields better achievement, other studies indicated the traditional method was better, and there are yet more studies that show there was no difference in achievement with either method. The last two studies revealed the need to probe further with specific subjects to examine which method is more effective for a specific set of circumstances (i.e. developmental, high achievers, algebra concepts, etc.).

Transfer of Knowledge

Of the various research available on teaching and learning mathematics, there seemed to be another important idea that emerge. This concept is an emphasis on teaching students mathematics in a manner that allows them to synthesis that knowledge and then transfer it to a variety of situations outside of the context in which they learned it, known to most researchers as transfer. Traditionally, transfer was thought of as a static process (Rebello et al., 2007). More recently, researchers have thought of transfer as a dynamic process in which social and cultural factors are considered; furthermore, transfer is considered from the students' perspective as opposed to the researchers' (Rebello et. al., 2007). More details on dynamic transfer will be discussed later. The themes behind the teaching and learning section of this literature review are found in all of the conclusions regarding math transfer studies presented in this section. The remainder of this section will elaborate on the best teaching practices that promote transfer in general (using general transfer studies), following this is an analysis of the current state of research of transfer specifically in mathematics and science.

Teaching for Transfer

When teaching mathematics it is important to do it in a way that puts emphasis on students learning it in a manner that allows them to synthesize that knowledge and transfer it to a variety of situations outside of the context in which they learned the material. The most common term for this is transfer (Bransford et al., 2000). The simplest meaning of transfer is when the learner can take what they have learned and apply it to a new situation (Bransford et al., 2000). Many educators and administrators would like students to take what they have learned and apply it to different situations. A study was done to address an issue on the minds of many superintendents, namely, how do you teach students so that they can use what they've learned in school when they graduate (Schwartz, Bransford, & Sears, 2005). In this study it was found that educators should go beyond teaching transfer through problem solving and teach with innovation and efficiency (Schwartz et al., 2005). The researchers also criticized most high stakes standardized testing because those tests, they argue, do not assess whether a student can really apply what they've learned to other situations (Schwartz et al., 2005). Instead these researchers argue for assessments that test transfer in non-traditional ways, such as the internet simulations and developing active problems that involve students working on with multiple real world issues and having to use their mathematical knowledge to solve those problems (e.g. running an airplane facility, calculating maintenance costs, fuel costs, etc, using spreadsheets and graphs to answer questions, etc.) (Schwartz et al., 2005). Essentially, the researchers were interested in answering the superintendents' question and part of the conclusions were to change the common popular assessment that many public schools utilize to test student academic achievement (Schwartz et al., 2005). Again, the administrators were interested in students being able to use their school knowledge in the real world after graduation with the goal of effectively teaching transfer. In another study on transfer, Bransford and Swartz (1999) reveals not only teaching transfer for direct application purposes but also for what he calls “preparation for future learning”. Using this approach the teacher would have in mind what they want students to be prepared for when they leave that setting and they would teach accordingly

(Bransford & Swartz, 1999). The important consequence of using this approach, if used in the manner described by Bransford, was that it would not only allow students to apply what they have learned but it eliminated previous misconceptions that they may have had about the subject matter.

In conclusion, it is important that students are shown and know how to use mathematics in situations outside of the mathematics context. Part of determining if mathematics was taught correctly was determining whether students could transfer mathematics. The studies mentioned in this literature review highlighted how one might go about in effectively teaching students how to use mathematics outside of the classroom. In terms of assessing mathematics transfer, much research needs to be done; however, the Schwartz et al. (2005) made clear that much of the high stakes state testing in public schools missed the mark. As revealed in the following transfer studies, none of the researchers have recommended standardized testing as a means to test for transfer.

Transfer in Mathematics and Science

Although none of the literature regarding transfer in mathematics and science analyzed the role confidence has on transfer, they did address transfer in terms of achievement (usually assessment results). Anecdotal evidence suggests that most students have difficulties transferring their math skills to physics and chemistry. Research, on the other hand, has revealed this phenomena to be true (Britton et al., 2005; Leopold & Edgar, 2008). The studies analyzing transfer in mathematics and science outlined in this section reveal the concepts discussed earlier in teaching and learning. Those concepts include emphasizing conceptual understanding in mathematics, teaching math classes with an emphasis on applications, and consideration of the students' cultural/social background when considering those applications.

Many of the mathematics and science transfer studies stressed teaching mathematics for conceptual understanding. Rebello et al., (2007) was a study designed to analyze whether students could transfer calculus and trigonometry to physics. This study considered transfer in terms of it being a dynamic process (Rebello et al., 2007). In doing so they examined the two types of transfer; horizontal and vertical (Rebello et al., 2007). Horizontal transfer "involves activation and mapping of new information into an existing knowledge structure" and Vertical transfer "involves creating a new knowledge structure to make sense of new information" (Rebello et al., 2007, p. 10). The general idea behind this research was to have students solve the standard plug and chug physics problems requiring horizontal transfer as well as semistructured problems (problems that involve more conceptual understanding, where students have to construct their knowledge and then transfer instead of using some existing knowledge structure to transfer like the horizontal transfer) requiring vertical transfer (Rebello et al., 2007).

Their results revealed that students do not seem to transfer well with horizontal transfer, however; the researcher might find proof of some transfer if he or she considered assessing via vertical transfer (Rebello et al., 2007). Obviously, this result led the researchers to conclude that more teachers should teach mathematics for conceptual understanding as well as doing more applications in mathematics (Rebello et al., 2007). Interestingly, even the students concurred about teaching mathematics with more applications (Rebello et al., 2007). This same conclusion of teaching for conceptual understanding and teaching mathematics with more applications revealed in this study was observed in many of the remaining studies in this section. The teaching methods revealed in this section were relevant for this study because the following studies that examined ability to transfer math skills to science reveal the same teaching methods described in this section as ways of improving transfer in students. The remaining research in this section will reveal technology integration and many other themes discussed in the teaching and learning section of this literature review.

Studies analyzing transfer of mathematics with early ages (K-12) revealed interesting results. Sometimes linguistics issues may be why students can not transfer (Koedinger & McLaughlin, 2010). Koedinger and McLaughlin (2010) involved a study focused on students being able to transfer algebraic symbols from word problems. This study involved 303 middle school students. The results from the study revealed that students had problems with transfer because of the grammar in the algebra stories. Interestingly, the researchers found that when students practiced similar algebra stories they improved transfer, which opposes the prevailing view that transfer would improve with practicing different problems. Again, as outlined in the teaching section, it is clear that this study confirms the method of teaching plays an important role in how students are able to transfer knowledge.

The next study will show the role that multidisciplinary collaboration has in influencing transfer. When analyzing math transfer with advanced secondary students, multidisciplinary teaching has been shown to increase the students' awareness of transfer (Andresen & Lindenskov, 2009). Anderson and Lindenskov (2009) conducted a case study in a Danish upper secondary school. In 2005 the government instituted mandatory multidisciplinary courses, where teams of different subject area teachers collaborated on a project in multidisciplinary teaching. The subjects involved in this project were math, physics, chemistry, and general studies preparation. Through observations and interviews the researchers found indications that students could see how to transfer math between the subjects, the positive and negative consequences of transferring knowledge between the subjects, and because of this the students could learn how the subjects related to each other.

Researchers have suggested that the concepts mention in the teaching and learning section of this literature review are the foundations for improving transfer, especially using non lecture related instructional materials (Bottge et al., 2004). As mentioned in the constructivist section, learning involves the learner constructing knowledge. One way to do this is the use of non lecture materials that will allow the learner to construct knowledge. The next study illustrates how non lecture materials improved transfer. Bottge et al. (2004) revealed that enhanced based instruction (which has a foundation in the constructivist learning perspective) was best for transfer. The Bottge, et. al. study involved 93 sixth graders students in an upper Midwest school that were studied for several months. The researchers wanted to compare the effects of teaching EAI (enhanced anchored instruction: includes hands on projects, real life problems, video compact discs, etc.) and TBI (text-based instruction) (Bottge et al., 2004). They found that students learned math well with both techniques, but the EAI students were able to transfer their learning weeks later. Part of the EAI activities in the Bottge et al. study utilized technology.

As mentioned earlier, technology has played a significant role in mathematics achievement and the next study demonstrates how this is also relevant to transfer. Research has shown that technology has a positive impact on transferring math skills (Clarke, 1993). Clarke (1993) was a study that analyzed math transfer for below-average sophomore math students. One of the goals of this study was to find out if computer assisted instruction or non computer assisted instruction was more effective in enabling students to transfer math skills. The results of this study revealed that computerized assisted instruction was better for these students.

Finally, a study examining how people use transfer in terms of “real world” situations, concludes that students must have a conceptual understanding of mathematics as well as be taught mathematics using real world applications (Boaler, 1993). Boaler (1993) analyzed several studies that researched how the general population applies math skills learned in school to the real world. Boaler concludes that students have a fundamental understanding of mathematics so that they can make those connections. Unlike most of the other studies that stressed applications, Boaler goes further and suggested that when using applications in mathematics they must be designed in terms of the students social and cultural values so that those problems will have meaning to the students. Boaler's suggestion of designing applications with a consideration of the social context can be credited to Vygotsky as discussed in the teaching and learning section of this literature review.

Post secondary knowledge transfer

The next set of research studies involved transfer of mathematics in the collegiate setting. Many of the conclusions and results are similar to those in the elementary and secondary setting. The constructivists' ideas about teaching and learning mathematics in a different context, multidisciplinary teaching, and teaching for understanding are especially prevalent in these studies.

The various conclusions seen here were evident in a study in which faculty at Pennsylvania State University considered when developing recommendations for designing courses that would better facilitate transfer of knowledge between various science disciplines (Benander & Lightner, 2005). Their study was initiated when faculty in the biology department realized that some students had trouble applying concepts learned in biology I to biology II. These recommendations were designed for those teaching all the general education courses, which included introductory chemistry, physics and mathematics. The section entitled *Previous math background* of this literature review discussed a study in which Johnson (1996) revealed that students with large gaps in their previous math background had a negative effect on achievement. Benander and Lightner (2005), even though this study was not focusing on achievement like the Johnson (1996) study was, recommended that students should take similar courses together and in sequence and minimize gaps between sequential courses (Benander & Lightner, 2005). Even though the Andresen and Lindenskov (2009) study involved secondary students, the Benander and Lightner study recommended a similar conclusion. Benander and Lightner also recommended that professors model transfer by practicing it in class (one way of doing this is having application subject area teachers come into the class to teach relevant topics so students can see how the topics are related) just as the Danish study did with multidisciplinary teaching (Benander & Lightner, 2005). Rebello et al. (2007) suggested that researchers would probably find transfer if they considered dynamic transfer which partly involves looking at it from the student's perspective (Rebello et al., 2007). Interestingly, one of the other recommendations of Benander and Lightner was to design classes that were centered behind how students think.

Those themes of transfer are also present with studies that examine specific math and science discipline topics. When examining a basic undergraduate chemistry class, researchers found that students had problems with transferring mathematics to chemistry but that transferring may not have been the real culprit; instead, lack of knowledge in specific area of mathematics was responsible (Potgieter et al., 2008). The researchers in this study had students work on chemistry problems using algebra and graphing skills, as well as pure math problems using the same skills but stripped of chemistry (Potgieter et al., 2008). The results of this study revealed that students had no problems with algebra on the chemistry and math problems, but the students had issues with graphing on both types of problems (the chemistry based and chemistry stripped problems). The researchers also found that students had problems connecting algebra to graphing. From these results the researchers concluded that transferring math skills was not the problem but the problem was that students do not have a good fundamental understanding of graphing. These researchers recommended that math teachers have students understand how to read graphs as well as how to connect algebra to graphs. Interestingly, many other researchers' results contrast to those of Potgieter et al. (2008).

Another study that took place in Australia analyzed transfer problems with logarithms and exponents, but unlike the Potgieter et al. (2008) study, the Australian researchers concluded that transfer was indeed the problem (Britton et al., 2005). Britton et al. (2005) did a study with students at the University of Sidney and was interested in how well students could transfer mathematics to computer science, biology, chemistry, and physics (Britton et al., 2005). The instrument they used involved students solving biology, chemistry, computer science, and physics problems using logarithms and exponents (Britton et al., 2005). These researchers found students did better with the 'pure' math problems than those that used the exact same skills but requiring transfer (Britton et al., 2005). Based on these results the Australian researchers recommended a previous idea mentioned before, that faculty in the different subject areas collaborate (Britton et al., 2005).

Researchers in Minnesota took a different approach than the previous collegiate studies mentioned here. Leopold and Edgar (2008) examined the issue of transfer with chemistry II students. These researchers used an instrument with pure math problems that were stripped of any chemistry content (it consisted of logarithms, scientific notation, graphing, and algebra) and they compared the students' results on this assessment to their final grade in chemistry II. Although the researchers found correlations between the math assessment and chemistry II achievement, they also found that the majority of students did not perform well on the math assessment (Leopold & Edgar, 2008). This last finding suggests that the poor math assessment results seen in Leopold and Edgar (2008) may coincide with the poor graphing skills seen in the Potgieter, Harding, and Engelbrecht study.

Finally, this last study suggests that this phenomena of students having difficulties transferring mathematics to physics and chemistry is not just limited to undergraduate freshmen and sophomores but also junior and seniors. Becker and Towns (2012) analyzed math transfer with physical chemistry students. These researchers were interested in whether physical chemistry students could effectively transfer their math knowledge of derivative and partial derivatives to thermodynamics problems. These researchers used talk aloud interviews and written assessments to collect their data. Their results mirror those of the Britton et al. (2005). Becker and Towns revealed that students could recognize the math concepts and have some understanding of partial as well as total derivatives; however, the students were not as successful in applying those math ideas to thermodynamics (Becker & Towns, 2012). One of the many conclusions these researchers recommended was one mentioned in several of the previous studies, that faculty from different subject areas collaborate.

In conclusion, the research on math transfer, whether at the elementary through secondary level or the collegiate level (beginning or advance) revealed that there is a problem with students learning math and applying it to physics or chemistry. As shown in this section some researchers found the problem may lie within the conceptual understanding of mathematics that students lack as the reason they have difficulties with transfer (Potgieter et al., 2008). This is one of the reasons these researchers argue that math teachers should focus more on making sure students develop a grounded conceptual understanding of mathematics. On the hand, there are other researchers that argued the problem lies in the application thereof, which is why many of these researchers argued that faculty from different areas collaborate. Regardless of the reasons, most researchers concluded that to help students more effectively transfer mathematics to physics and chemistry, math teachers should teach for conceptual understanding, include real world math examples that consider the social/cultural background of the students, and make effective use of technology.

Attitudes and Feelings Regarding Mathematics

Self-efficacy has been defined as by Choi (2005) in reference to Bandura as "refers to an individual's perceived capability in performing necessary tasks to achieve goals" (p. 197). Becker and Gable (2009) define self-efficacy as "beliefs in one's capability" (p. 3). The researcher will use this term as a board term that encompasses confidence. Confidence, is the key construct used as a measurable variable in this study that is defined in chapter one as the certainty in one's beliefs regarding their capability. The remainder of this section will illuminate the various studies that show how a students' beliefs, feelings, or attitudes in mathematics has, and impact on math performance. These beliefs or feelings range from confidence, self-concept, and Math anxiety. The present study is specifically designed to measure confidence, but as such, it is defined earlier as a certainty of a belief that the students have about their ability in mathematics. The closest studies that involve beliefs or attitudes that students have in mathematics include math anxiety (Ashcraft, 2002; Beilock, Gunderson, Ramirez, & Levine, 2010; Cates & Rhymer 2003; Kazelskis et al., 2000; Woodward, 2004), self-concept (Starobin & Laanan, 2005; Skaalvik & Skaalvik, 2004), self-efficacy (Becker & Gable, 2009; Choi, 2005), and epistemological beliefs (Schommer-Aitkins, Duell, & Hunter, 2005). The remainder of this section will highlight what the literature has revealed regarding math anxiety, self-concept, self-efficacy (confidence as the researcher has defined it in chapter one), and epistemological beliefs regarding mathematics and how or if these constructs have been prevalent in mathematics performance.

Math anxiety

In terms of elaborating on the beliefs, feelings, or attitudes students have about mathematics, it is important to consider math anxiety. Math anxiety is defined by Woodward (2004) as “feelings of tension and anxiety that interfere with the manipulation of mathematical problems in a wide variety of ordinary life and academic situations” (p. 1). One researcher, Ashcraft (2002), defines math anxiety in a slightly different way “feelings of tension, apprehension, or fear that interferes with math performance” (p. 181). Regardless of the definition, it is apparent from the research that the great majority of the studies on math anxiety show that high levels of math anxiety result in lower mathematics achievement (Ashcraft, 2002; Beilock et al., 2010; Kazelskis et al., 2000; Woodward, 2004).

Woodward, for example, analyzed math anxiety using the mathematical anxiety rating scale (MARS) instruments to measure mathematical anxiety. This survey was given to 120 community college students and it was found that there was a negative relationship between math anxiety and exit exam scores (Woodward, 2004). The results from this study also revealed that female students were more anxious than males (Woodward, 2004). This finding is very similar to those mentioned in the “Gender” section of this chapter in which females on the collegiate level were found to have lower math/science achievement results.

In terms of gender, it was found that a female teacher's math anxiety can influence the attitude her students have towards mathematics (Beilock et al., 2010). The Beilock et al. study focused on 17 first and second grade female teachers. They had the teachers do the MARS test as well as the elementary number concepts and operations subset of the content knowledge for Teaching mathematics measure. The students were given a pre test and a post test using the Woodstock-Johnson III test of achievement. The results from this analysis revealed in the beginning the female teachers' math anxiety had no effect on the students, but the post test revealed that the female students’ performance was negatively by the female teachers' high math anxiety. The study goes further to reveal that this had no effect on the male students, and the girls began to accept that boys were superior in mathematics.

Again, the results from this study correlate with those seen in “Gender” section of this chapter. The remainder of the studies on anxiety using the MARS instrument have similar conclusions in terms of high math anxiety relating to low math achievement. Ashcraft (2002) was a synthesis study that reviewed all other math anxiety studies that utilized the MARS instrument and their analysis revealed a negative correlation between math anxiety and math performance. Similarly, Kazelskis et al., (2000), surveyed 321 students taking a freshman college algebra class at a university and used a revised form of the MARS instrument to measure anxiety, the math anxiety questionnaire (MAQ), and the math anxiety survey (MAS). The Kazelskis et al. (2000) results revealed that there is a strong correlation between test anxiety and math anxiety. They are very careful in pointing out that the results do not mean the two are the same, but that they are highly related to each other (Kazelskis et al., 2000).

So far, all the studies utilizing the MARS instrument in some form have found that high math anxiety has a negative impact on math achievement. Although all of these studies reveal that high math anxiety has some negative effect on math achievement, not all researchers agree (Cates & Rhymer, 2003). The Cates and Rhymer (2003) study revealed a different conclusion. This study solicited over 500 students and only collected data on 52 students, 40 female and 12 male, the students were surveyed using the Fennema-Sherman Mathematics Anxiety Scale (FSMAS) as well as having students actually do a test involving basic mathematical operations. Students were put in high anxiety and low anxiety groups. Unlike the pervious MARS studies, this study revealed not statistically significant difference in errors by either group. However, they did find that even though their errors were relatively the same, the low anxiety group did do the work quicker, more efficiently, and utilized the least effort.

Interestingly, Dogbey (2010) was a study done with developmental math students at six community colleges. Like the Cates and Rhymer (2003) study these students in this study filled out the FSMAS instrument regarding their attitudes towards mathematics. Unlike the MARS studies, the statistical analysis from this study revealed that most students had a positive attitude towards mathematics (Dogbey, 2010). In summary, the evidence from the research on math anxiety indicates that there is a gender difference and depending on the instrument being used, anxiety may or may not have a negative impact on math achievement. The next section will highlight the constructs of self-efficacy (confidence), self-concept, and their impact on math achievement.

Self-efficacy and Self-concept

Self-efficacy is defined by Choi (2005) in reference to Bandura as referring "to an individual's perceived capability in performing necessary tasks to achieve goals" (p. 197). It is also defined by Becker and Gable (2009) as "belief in one's capability" (p. 3).

Becker and Gable (2009) gave 194 community college students a self-efficacy questionnaire, developed by the researchers, asking very board general self-efficacy math questions (i.e. "I am confident I can...", etc.). These researchers linked the questionnaire results with the students' GPA and found that self-efficacy, while statistically significant, accounted for only 5% in the variance of GPA (Becker and Gable, 2009). The low variance number could be explained by the very general and board self-efficacy instrument used by the researcher (Choi, 2005), as well as the fact that an overall GPA was used instead of the grades related to math or science. Choi links the survey to the class grades and the variance nearly doubles. Choi (2005) was a research study that analyzed self-efficacy and self-concept. Choi (2005) explains that many researchers commonly link self-concept and self-efficacy as the same construct, but the difference is that self-concept is only different by the fact that the comparison is referenced to others, while self-efficacy is referenced to one's past. Choi (2005) surveyed 230 university students using the College academic self-efficacy scale (CASES), designed to "measure the degree of confidence of performing typical academic behaviors of college students" (p. 200). To measure self concept Choi used the academic self-concept scale (ASCS). Choi linked the results of the survey to the students' class grades and found that self-efficacy accounted for 10% of the grade variance while self-concept accounted for 20% of the variance.

These two studies indicate that self-efficacy and self-concept are significant factors in a students' GPA or grades. The fact that these studies reveal that no more than 20% of the variance being accounted for by self-concept or self-efficacy, elucidates to speculation as to what other factors account for the remaining 80% of the variance. Perhaps, controlling other factors that affect self-concept or self-efficacy might yield a higher variance for self-concept and self-efficacy than those revealed by the Becker and Towns (2012) as well as the Choi (2005) studies.

One of the factors that are statistically significant in self-concept is gender (Skaalvik & Skaalvik, 2004). The Skaalvik and Skaalvik (2004) study examined 907 students in from elementary to high school. These researchers surveyed the students using a modified version of the self description questionnaire. The analysis revealed that males had more self-concept than females (Skaalvik & Skaalvik, 2004). Not only has gender been revealed to be a statistically significant factor in anxiety and achievement, but this study confirms the same is true with self-concept.

Gender is not the only factor influencing self-concept, previous high school performance and learning environments are also factors that have been shown to be statistically significant factors influencing self-concept (Starobin & Laanan, 2005). The Starobin and Laanan (2005) study analyzed data from the 1996 Cooperative institute research program (CIRP) freshman survey, using 1,599 Science, Engineering, and Math majors at a community college. It should be noted that the definition on self-concept in this study is a little different, Starobin and Laanan define self-concept as “confidence in learning mathematics...” (p. 212). The analysis from the Starobin and Laanan study revealed learning environment and high school performance were significant predictors for self-concept.

In summary, whether researchers look at the students' belief as defined by self-efficacy (confidence) or self-concept (referenced to other students), the research indicates that either variable has been shown to have an effect on achievement. Furthermore, gender and high school performance were shown to be predictors for self-concept. As mentioned in the section 'previous math background', those studies indicated that the previous math background had an effect on the students’ achievement in college, and these studies have shown that the same is true for self-concept.

CHAPTER III

METHODOLOGY

The purpose of this study was to examine the confidence that community college students have in regards to applying specific basic math skills to science classes, as well as any factors that influence confidence levels. This chapter describes the research design, participants, instrumentation, procedures, limitations, and analysis of data.

Research Questions

This research answered the following questions:

Question 1: What factors (Age, gender, enrollment status, science course currently taking, homework method, grades in previous math class, previous math class taken, retaking the present science class, midterm grade in this science class, current degree level, and hours of study) contribute the most and to what extent to students reported confidence levels in applying math skills?

Question 2: Which science classes (chemistry, physics (both calculus and algebra based), physical science, chemistry II, physics II (both calculus and algebra based), and principles of chemistry) do students report having the least and greatest confidence in applying math skills?

Question 3: Which math skills (fractions logarithms, ratios, slope, conversions, solving algebraic expressions, scientific notation, arithmetic operations, and graphing) do students have the most and least confidence in applying to science?

Question 4: Is there a relationship between confidence in the ability to transfer and the reported grade in the science course?

Question 5: What level of confidence do students have in the ability to do problems that utilize pure math skills?

Question 6: Do the student have the most or least confidence in transferring basic math skills to chemistry, physics, principles of chemistry, or physical science related applications.

Hypotheses

H_1: Age, gender, enrollment status, science course currently taking, homework method, grades in previous math class, previous math class taken, retaking the present science class, midterm grade in this science class, current degree level, and hours of study do not account for variance in the overall mean confidence score.

H_2: There is no significant difference in overall confidence scores between the science course currently taking (chemistry, physics (both calculus and algebra based), physical science, chemistry II, physics II (both calculus and algebra based), and principles of chemistry).

H_3: There is no significant difference between the repeated measures basic math skills (fractions logarithms, ratios, slope, conversions, solving algebraic expressions, scientific notation, arithmetic operations, and graphing).

H_4: There is no significant difference in overall confidence scores between midterm grade in this science class and the overall mean confidence score.

H_5: There is no statistical difference in confidence between physics, chemistry, physical science, or principles of chemistry related confidence items.

Research Design

The research questions were investigated using a survey instrument (Appendix A), specifically designed by the researcher based on the review of literature above. The instrument was examined by a panel of experts and revised according to suggested changes. The panel of experts included two chemistry instructors and two physics instructors at a community college. This survey instrument was pilot tested with nine students from a Physical Science and a Physics lab. This pilot study results revealed an overall Chronbach alpha's score of 0.902. The lowest Chronbach alpha's score on each likert scale type question was 0.891. With this data the researcher proceeded with the full study. The independent variables that came from the survey instrument were age, gender, education, enrollment status, previous math course taken, homework method, present science class currently taking, grades in previous math class, retaking the present science class, midterm grade for the present class, and hours of study. The survey instrument in this research design included the dependent variables of confidence in specific basic mathematics skills. Within the general category of confidence are subcategories defined under "Instrumentation." Only those subcategories with valid Chronbach alpha values were included in the survey taken by the students. The survey was taken by students only once in their science class after midterm grades were given.

Participants

The participant pool for this research design consisted of students who attended a community college in central Mississippi and varied in age from eighteen to fifty years of age. The race of the participants included students who identified as White, Black, Asian, and Hispanic. The socioeconomic level of the students also varied and was not measured. The researcher anticipated a sample size of approximately 100 respondents, but received 196 responses from the paper instrument. The researcher contacted physics and chemistry community college instructors to distribute the survey to their students. The students volunteered to take the survey.

Instrumentation

The survey instrument (Appendix A) for this research study was designed by the researcher. The instrument included common demographic data such as age, gender, and education level. Other survey items included questions about enrollment status, course taken, homework method, science class, grades in previous math class, retaking the class, midterm grade, and hours of study. Enrollment status was chosen for the survey by the researcher because there was little conclusive research that examined the confidence in mathematics based on enrollment status. The Bahr (2008) study examined community college achievement in mathematics with remedial students verses traditional students and found “comparable outcomes” (p. 420). Confidence was not the focus in this study and as such the researcher has included this component in the survey to see if the previous mathematics courses taken was a significant predictor in confidence level. Homework method of the previous math class was chosen because as seen in chapter two, the research is conflicted as to whether the method of practicing homework makes a difference in learning outcomes with basic math skills. The rest of the variables were chosen for the same reason. None of the studies examined in the literature examine the variables listed in this survey and confidence in transfer of basic math skills.

The last fourteen questions on the survey (items 33-46) are the independent variables. Questions that are the dependent variables related to confidence in transfer of specific basic math skills. More specifically, embedded in the confidence test was a subtest of confidence that included: fractions (items 7 & 16), logarithms (items 28-30), ratios (item 4), slope (items 5-6 & 25-27), conversions (items 8-10), solving algebraic expressions (items 11-13), scientific notations (items 14-16), arithmetic operations (items 18-21), and graphing (items 22-24 & 1-3). Furthermore, within those subcategories of confidence were items that measured confidence in terms of basic pure math skills, application of those math skills to chemistry, physics, physical science and principles of chemistry. Items 1 (graphing), 4 (ratios), 7 (fractions), 11 (solving algebraic expression), 14 (scientific notation), 18 (arithmetic operations), 22 (graphing), 25 (slope), & 28 (logarithms) involve measuring confidence in basic pure math skills. Items 2 (graphing), 15 (slope), 8 (conversions), 12 (solving algebraic expressions), 15 (scientific notation), 19 (arithmetic operations), 23 (graphing), 26 (slope), and 29 (logarithms) measured confidence in transferring math skills to chemistry related applications. Items 3 (graphing), 6 (slope), 9 (conversions), 13 (solving algebraic expressions), 16 (scientific notation), 20 (arithmetic operations), 21 (arithmetic operations), 24 (graphing), 27 (slope), and 30 (logarithms) measured confidence in transferring basic math skills to physics related applications. Items 10 (conversions) and 17 (fractions) relate transferring respective math skills to physical science and principles of chemistry applications. The overall mean confidence score was a mean average of all the subcategories taken together. To test for confidence in specific math skill as hypothesized in the third hypothesis, the researcher examined variance between the subcategories of confidence (collapsing across chemistry, physics, physical science, or principles of chemistry application).

This instrument was pilot tested was given to students taking a general physics and physical science class at a community college in central Mississippi. The pilot test of this instrument took place after midterms. The researcher analyzed the results for ways or means of improving the survey instrument and there was no need to do so. All statistical analysis needed to test the validity of the instrument as well as running the required tests to answer the research questions were done by the researcher using SPSS.

Procedures

The survey was distributed to students in the fall of 2012 after midterms. Before distribution it was pilot tested and validated. The researcher sought approval from the Institution Review Board before any research was attempted with human subjects. To ensure compliance with regulations, the researcher had already taken the necessary responsible conduct in research training courses and was certified to conduct research. In gaining the approval of the University of Southern Mississippi Institutional Review Board (Appendix B), the researcher submitted with the approval documentation permission from the president of the community college (Appendix C) to conduct the study. Once that permission was granted the researcher asked for permission from the science instructors to distribute the survey to their students. The students were informed that their consent is completely voluntary and all information would remain anonymous. The students who volunteered were given the survey to complete. The students were given approximately thirty minutes to complete the survey on paper and they turned it in to the instructor distributed the survey (who returned them to the researcher).

Data Analysis

The student responses from the instrument were entered into the latest version of SPSS by the researcher. The researcher analyzed the first hypotheses by conducting a multiple regression test using the listed independent variables as predictors and the overall mean confidence score as the dependent variable. Next, the researcher analyzed the second hypothesis by performing an ANOVA using the science class currently taking as the independent variable and the overall mean confidence score as the dependent variable. To examine the third hypothesis the researcher performed a repeated measures ANOVA examining significance between basic math skills (fractions, logarithms, ratios, slope, conversions, solving algebraic expressions, scientific notation, arithmetic operations, and graphing) confidence scores. For the fourth hypothesis the researcher performed an ANOVA between the midterm grade score and overall confidence score. The last hypothesis was analyzed using a repeated measures ANOVA design by analyzing the variances in confidence scores between the groups of physics, chemistry, and principles of chemistry/physical science, more specifically, the items from the survey that related to these groups are as follows: Items 2, 5, 8, 12, 15, 19, 23, 26, and 29 measured confidence in transferring math skills to chemistry related applications defined as the chemistry group. Items 3, 6, 9, 13, 16, 20, 21, 24, 27, and 30 measured confidence in transferring basic math skills to physics related applications defined as the physics group. Items 10 and 17 related transferring respective math skills to physical science and principles of chemistry applications defined as the physical science/principles of chemistry group.

For most of the open ended questions, most students left those questions unanswered, as a result, the researcher could not analyze any conclusive results from the few responses given.

CHAPTER IV

ANALYSIS OF DATA

Introduction

The main purpose of this research was to examine, from a statistical perspective, the various factors that affect the confidence community college students have in transferring their mathematical skills to physics and chemistry courses. The researcher devised a survey instrument (Appendix A) designed to analyze the students' confidence. The students who took the survey were instructed to rate how confident they were in solving math problems involving logarithms, conversions, slope, fractions, etc. The students were also directed to rate their confidence in solving physics and chemistry based problems involving those math skills. The researcher was interested in which demographic factors were significant and how much of a predictor they were in determining a student's confidence score. The researcher was also interested in which specific math skills the students reported the most and least confidence, which science related problems the students were most and least confident in transferring math skills, as well as which science courses reported the most and least confidence scores and whether those differences were statistically significant.

The survey instrument was distributed to all of the full time physics and chemistry instructors at the community college. These instructors distributed paper copies of the survey instrument for their students to voluntarily complete in their respective lab courses. At the completion of this study, 196 students who were taking physics (algebra based), physics (calculus-based), physical science, principles of chemistry, and chemistry II completed the survey.

Descriptive Data

This study was conducted at a community college in the Fall of 2012. Table 1 provides the demographic background of the participants in this study. As shown in Table 1, the majority of the students in this study were between the ages of 18-22 (76.5%). Males slightly outnumbered the females (50.5%), and the great majority of students reported their enrollment status as full time students (85.2%). In terms of degree status, most of the participants reported a high school diploma as their highest degree obtained (78.6%).

Table 1

Demographic Information (Age, Gender, Status, and Degree)

		Frequency	Percent
Age			
	18-22	150	76.5
	23-27	29	14.8
	28-32	4	2.0
	33 and Over	12	6.1
	No Response	1	.5
Gender			
	Male	99	50.5
	Female	96	49.0
	No Response	1	.5
Status			
	Full-time	167	85.2
	Part-time	27	13.8
	No Response	2	1
Degree			
	High school diploma	154	78.6
	GED	5	2.6
	Associate degree	17	8.7
	Bachelor's or higher	18	9.2
	No Response	2	1.0

The descriptive statistics in Table 2 provides statistical information regarding the mathematical background of the participants in the study. As shown in Table 2, the majority of students reported taking college algebra as their first math class (37.2%) but the next highest group reported taking a developmental math course, intermediate algebra (29.1%) as their first college mathematics course. In terms of the grade in the previous math class, most students reported earning a B (42.3%). Most of the students who participated in this survey reported taking their math class only once (85.2%). Finally, in terms of doing their homework, the students were evenly tied between having done their mathematics homework online (38.3%) and a combination of paper/pencil with online (38.3%).

Table 2

Mathematics Background (Class, Grade, Retake, and Homework)

		Frequency	Percent
First Mathematics Class			
	Calculus	16	8.2
	Trigonometry	10	5.1
	College Algebra	73	37.2
	Intermediate Algebra	57	29.1
	Beginning Algebra	27	13.8
	Fundamentals of Mathematics	8	4.1
	No Response	5	2.6
Previous Mathematics Grade			
	A	59	30.1
	B	83	42.3
	C	32	16.3
	D	14	7.1
	F	3	1.5
	No Response	5	2.6
Retook Mathematics Course			
	Yes	27	13.8
	No	167	85.2
	No Response	2	1.0
Homework Method			
	Paper and Pencil	43	21.9
	Online	75	38.3
	Combination of both	75	38.3
	No Response	3	1.5

The descriptive statistics in Table 3 provide statistical information relating to the science background of the participants. Most of the participants in this study were taking Physical Science (35.7%). Just as the majority of the participants reported taking their previous math class once, the overwhelming majority of students reported taking the present science class only once (85.7%). As with their previous mathematics class, most students reported having a B as their midterm grade in their current science class (28.6%). In terms of study time outside of the class, most of the respondents reported only studying for this class between 0 to 3 hours a week (65.3%).

Table 3

Science Class Status (Class, Retake, Grade, and Study Time)

		Frequency	Percent
Current Science Class			
	Physical science	70	35.7
	Physics (calculus-based)	14	7.1
	Physics (algebra-based)	31	15.8
	Chemistry	56	28.6
	Principles of Chemistry	16	8.2
	Chemistry II	7	3.6
	No Response	2	1.0
Retaking Science Class			
	Yes	27	13.8
	No	168	85.7
	No Response	1	.5
Reported Midterm Grade			
	A	40	20.4
	B	56	28.6
	C	42	21.4
	D	28	14.3
	F	26	13.3
	No Response	4	2.0
Home Study Time			
	0-3hrs	128	65.3
	4-7hrs	51	26.0
	8-11 hrs	10	5.1
	11 or more hours	5	2.6
	No Response	2	1.0

The descriptive statistics for Table 4 correspond to the science class the students were currently taking. As shown in Table 4, the class with the highest average confidence score was the calculus-based physics class. Their mean confidence score was 3.63 with a standard deviation of .29. The class with the lowest mean confidence score was chemistry. The students taking chemistry had a mean confidence score of 3.26 with a standard deviation of .52. The overall mean confidence score for all students was 3.31 with a standard deviation of .50. Only the physical science and chemistry students had mean confidence scores below the overall mean.

Table 4

Descriptive Statistics for Science Class Confidence Scores

	Mean	Minimum	Maximum	St. Dev.
Physics (calculus-based)	3.63	3.17	4.00	.29
Physics (algebra-based)	3.50	2.46	4.00	.41
Principles of Chemistry	3.41	2.48	3.82	.33
Chemistry II	3.36	2.83	3.83	.36
Chemistry	3.25	1.86	4.00	.52
Physical Science	3.19	1.71	4.00	.54
All	3.31	1.71	4.00	.50

Note: The confidence scores were based on a 4 point scale, where 1 = "completely disagree", 2 = "somewhat disagree", 3 = "somewhat agree", & 4 = "completely agree"

The descriptive statistics for Table 5 corresponded to math skills. As shown in Table 5, the math skill the students had the highest confidence in was algebra operations with a mean of 3.69 and a standard deviation of .51. The math skill students had the lowest confidence in was logarithms with a mean of 2.83 and a standard deviation of .79.

Table 5

Descriptive Statistics for Math Skills (N = 165)

	Mean	Std. Dev.
Algebraic Expressions	3.69	.51
Ratios	3.65	.67
Conversions	3.63	.48
Scientific Notation	3.47	.70
Fractions	3.46	.68
Arithmetic Operations	3.30	.63
Graphing	3.30	.62
Slopes	2.92	.76
Logarithms	2.83	.79

Note: The confidence scores were based on a 4 point scale, where 1 = "completely disagree", 2 = "somewhat disagree", 3 = "somewhat agree", & 4 = "completely agree"

The descriptive statistics for Table 6 corresponds to the midterm grade reported by the students. As shown in Table 6, the students with the highest confidence scores were the students who reported a midterm grade of A. The students who reported a midterm grade of A had a mean of 3.49 with a standard deviation of .38. The students with the lowest confidence scores were the students who reported a midterm grade of F. The students who reported a midterm grade of F had a mean confidence score of 3.09 with a standard deviation of .54.

Table 6

Descriptive Statistics for Midterm Grade

	n	Mean	Minimum	Maximum	Std. Dev.
A	40	3.49	2.50	4.00	.38
B	56	3.42	1.71	4.00	.51
C	42	3.31	2.20	4.00	.50
D	28	3.09	2.10	3.86	.42
F	26	3.09	1.87	3.97	.54
All	192	3.32	1.71	4.00	.50

Note: The confidence scores were based on a 4 point scale, where 1 = "completely disagree", 2 = "somewhat disagree", 3 = "somewhat agree", & 4 = "completely agree"

The descriptive statistics in Table 7 relate to the type of science problems that utilize math skills for all students. As shown in Table 7, the science application questions students reported the highest confidence in was physical science and principles of chemistry, with a mean of 3.68 and a standard deviation of .53. On the other hand, the science application questions for which students reported the least confidence in was chemistry, with a mean of 3.03 and a standard deviation of .69.

Table 7

Math Related Science Application Descriptive Statistics (N = 91)

	Mean	Std. Dev.
Physical Science & Principles of Chemistry	3.68	.53
Physics	3.19	.62
Chemistry	3.03	.69

Note: The confidence scores were based on a 4 point scale, where 1 = "completely disagree", 2 = "somewhat disagree", 3 = "somewhat agree", & 4 = "completely agree"

Test of Hypotheses

The hypotheses for this research study are stated below along with the results found.

Hypothesis 1: Age, gender, enrollment status, science course currently taking, homework method, grades in previous math class, previous math class taken, retaking the present science class, midterm grade in this science class, current degree level, and hours of study do not account for variance in the overall mean confidence score.

The researcher analyzed the first hypotheses by conducting a multiple regression test using the listed independent variables as predictors and the overall mean confidence score as the dependent variable. The results of this model for the regression analysis accounted for 37.3% of the variance with $R = 0.61$. Furthermore, the model for this regression analysis was revealed to be significant, $F(40, 152) = 2.26$, $p < .001$. Only age, science class currently taking, retaking a math course, and whether the participants felt their previous math course prepared them for the science class they were currently taking were significant predictors for confidence. Table 8 is a statistical summary of those significant predictors. In regards to age, the 18-22 group was statistically significant, β = -0.25, $t(196) = -2.56$, $p = .012$. In regards to the science class currently taking, the principles of chemistry group was statistically significant, $\beta = .17$, $t(196) = 2.19$, $p = .03$. Retaking the math course was statistically significant, $\beta = -.24$, $t(196) = -3.24$, $p = .001$. Feeling that the previous math class helped prepare for the current science class was statistically significant, $\beta = .24$, $t(196) = 3.08$, $p = .002$.

As shown in Table 8, controlling for all other predictors, students who belonged to the age group 18-22 had confidence scores 0.30 lower than students of the other age groups, students taking principles of chemistry had confidence scores 0.30 higher than students taking other courses, students who reported retaking their previous mathematics class had confidence scores 0.35 lower than students who did not report retaking their previous mathematics class, and students who believed that their previous math class prepared them for the current math class had confidence scores 0.25 higher than those students who did not believe their previous math class prepared them for the current math class.

Hypothesis 1 was rejected because the analysis that revealed age, current science class taking, retaking the course, feelings of math preparation were found to account for variance in overall mean confidence scores.

Hypothesis 2: There is no significant difference in overall confidence scores between the science course currently taking (chemistry, physics (both calculus and algebra based), physical science, chemistry II, physics II (both calculus and algebra based), and principles of chemistry).

The researcher analyzed the second hypothesis by performing an ANOVA using the science class currently taking as the independent variable and the overall mean confidence score as the dependent variable.

The results of this analysis in Table 4 revealed there was an effect on the overall mean confidence score based on the science class $F(5, 188) = 3.33$, $p = .007$. Further analysis from a post-hoc test, utilizing the Tukey-HSD method, revealed a statistically significant difference in mean confidence scores between physical science (M = 3.19, S.D. = .54) and calculus-based physics (M = 3.63, S.D. = .29), $p = .026$. There was also a statistically significant difference in overall mean confidence scores between physical science (M = 3.19, S.D. = .54) and algebra-based physics (M = 3.50, S.D. = .42), $p = .039$.

Because it was found that there was a statistically significant difference in overall mean confidence scores between the physical science and calculus-based physics as well as between physical science and algebra-based physics the research has rejected hypothesis 2.

Hypothesis 3: There is no significant difference between the repeated measures basic math skills (fractions logarithms, ratios, slope, conversions, solving algebraic expressions, scientific notation, arithmetic operations, and graphing).

The researcher performed a repeated measures ANOVA examining significance between basic math skills (fractions, logarithms, ratios, slope, conversions, solving algebraic expressions, scientific notation, arithmetic operations, and graphing) confidence scores.

The results of the analysis in Table 5 indicated a significant difference between the groups for math skills based on confidence score, Wilks' Lambda = .36, $F(8, 157) = 35.18$, $p < .001$.

This analysis was followed by post-hoc analysis using pairwise comparison. The results of this analysis revealed that there was a statistically significant difference between fractions (M = 3.46, S.D. = .68) and logarithms (M = 2.83, S.D. = .79), $p <.001$; fractions (M = 3.46, S.D. = .68) and ratios (M = 3.65, S.D. = .67), $p = .001$; fractions (M = 3.46, S.D. = .68) and slopes (M = 2.91, S.D. = .76), $p < .001$; fractions (M = 3.46, S.D. = .68) and conversions (M = 3.63, S.D. = .48), $p < .001$; fractions (M = 3.46, S.D. = .68) and algebra operations (M = 3.69, S.D. = .51), $p < .001$; fractions (M = 3.46, S.D. = .68) and arithmetic operations (M = 3.30, S.D. = .63), $p = .001$; fractions (M = 3.46, S.D. = .68) and graphing (M = 3.30, S.D. = .62), $p < .001$; logarithms and ratios, $p < .001$; logarithms and conversions, $p < .001$; logarithms and algebra operations, $p < .001$; logarithms and scientific notation (M = 3.47, S.D. = .70), $p < .001$; logarithms and arithmetic operations, $p < .001$; logarithms and graphing, $p < .001$; ratios and slopes, $p < .001$; ratios and scientific notation, $p = .006$; ratios and arithmetic operations, $p < .001$; ratios and graphing, $p < .001$; slopes and conversion, $p < .001$; slopes and algebraic expressions, $p < .001$; slopes and scientific notation, $p < .001$; slopes and arithmetic operations, $p < .001$; slopes and graphing, $p < .001$; conversions and scientific notation, $p < .001$; conversions and arithmetic operations, $p < .001$; conversions and graphing, $p < .001$; algebraic operations and scientific notation, $p < .001$; algebraic operations and arithmetic operations, $p < .001$; algebraic operations and graphing, $p < .001$; scientific notation and graphing, $p < .001$; scientific notation and algebraic operations, $p < .001$.

The results of this repeated measures ANOVA indicated that there was significance in confidence scores between the math skills groups. Because of this significance, the researcher rejected hypothesis 3.

Hypothesis 4: There is no significant difference in overall confidence scores between midterm grades in this science class.

The researcher performed an ANOVA between the midterm grade score and overall confidence score.

The results of the ANOVA analysis in Table 6 revealed that there was a statistically significant difference between the midterm grade groups. The results indicated significance, $F(4, 187) = 5.01$, $p < .001$. Further analysis was followed up with a post-hoc analysis using, the Tukey-HSD, multiple comparison analysis.

The results from the post hoc analysis indicated a statistically significant difference between students who reported a midterm grade of A (M = 3.49, S.D. = .38) and D (M = 3.09, S.D. = .42), $p = .007$; A and F (M = 3.09, S.D. = .54), $p = .009$; B (M = 3.42, S.D. = .51) and D, $p = .027$; B and F, $p = .036$.

Because the researcher found a statistically significant difference between the midterm grades and overall confidence score, the researcher has rejected hypotheses 4.

Hypothesis 5: There is no statistical difference in confidence between physics, chemistry, physical science, or principles of chemistry related confidence items.

The researcher analyzed this hypothesis using a repeated measures ANOVA design by analyzing the variances in confidence scores between the groups (as defined in the data analysis section) of physics related applications, chemistry related applications, and principles of chemistry/physical science related applications.

The results of the analysis in Table 7 indicated a significant difference between the groups for science related applications based on confidence score, Wilks' Lambda = .51, $F(2, 189) = 92.68$, $p < .001$.

This analysis was followed by post-hoc analysis using pairwise comparison. The results of this analysis revealed that there was a statistically significant difference between chemistry (M = 3.03, S.D. = .69) and physics (M = 3.19, S.D. = .62), $p < .001$; chemistry and physical science/principals of chemistry (M = 3.68, S.D. = .53), $p < .001$; physics and physical science/principals of chemistry, $p < .001$.

As a result of the significance found with this repeated measures analysis the researcher has rejected hypothesis 5.

Table 8

Coefficients for the Predictor Variables

	B	β	*t*	*p*
(Constant)	3.46		4.61	.000
Age 18-22	-.30	-.25	-2.56	.012
Age 28-32	-.20	-.06	-.78	.439
Age 33&up	-.10	-.05	-.56	.575
Physics (Calculus)	.17	.09	1.03	.304
Physics (Algebra)	.11	.08	.88	.381
Chemistry	.17	.15	1.63	.106
Principles of Chemistry	.30	.17	2.19	.030
Chemistry II	.33	.13	1.53	.127
Retook previous math class?	-.35	-.24	-3.24	.001
Math class prepared them for science	.25	.24	3.08	.002

Note: Dependent Variable is confidence

In summary, the statistical analysis from this study as shown in Table 8 has revealed that 37% of the variance in confidence scores could be accounted for by the respondent's age, current science class taking, retaking the course, and feelings of math preparation. It was also found that there was a statistically significant difference in overall mean confidence scores between the physical science and calculus-based physics as well as between physical science and algebra-based physics. There was significance in confidence scores between the math skills groups and it was found that there was a statistically significant difference between the midterm grades and overall confidence score. Finally, the data revealed that there was significance in confidence score based on which science class the mathematics was being transferred to.

CHAPTER V

CONCLUSIONS AND DISCUSSION

Introduction

The purpose behind this study was to gain an understanding, from a statistical perspective, about how confident students are in transferring basic math skills to physics and chemistry related courses. The goal of this study was to gather relevant statistical information regarding how confident the students feel they could transfer their mathematics knowledge to physics and chemistry as well as which areas were the best or worst for transfer. This statistical information would allow future researchers to focus on those specific math skills or specific students (based on demographic statistics) in which the data indicated had low confidence scores. The statistical information revealed in this study would provide statistical information which math and science educators can focus for mathematics and science transfer studies.

Summary of Procedures

This study was conducted with students at a community college in central Mississippi. The study was conducted during the month of November after all of the students finished taking midterm exams and had already received their midterm grades at that point.

The instrument used in this survey was developed by the researcher based on the available literature, consulting the instructors that teach the subject areas targeted in this study, as well as students who were taking the classes relevant to the study. A pilot study was conducted with an overall Chronbach's alpha of .90. After the pilot study, at the request of the researcher, the science instructors distributed paper copies of the instrument to their students during lab. After the students completed the survey, the science instructors returned them to the researcher. The researcher input the data from the paper surveys into IBM SPSS statistics version 20 for data analysis. To answer the research hypothesis, the researcher performed ANOVA, multiple regression, and repeated measures ANOVA analysis (significance as defined at the .05 level).

Conclusions

Age, current science course, whether they retook their previous math class, and whether they felt their previous math class prepared them for their current math class were significant predictors for confidence. The analysis of this regression indicated that these predictors were significant in how confident students were about their ability transfer mathematics to science. The analysis revealed that a student in the 18-22 age range was likely to have a lower confidence score than the average student. This analysis implies that younger students do not have as much confidence in their ability to transfer mathematics to science as older students do. In terms of the current science course, because principals of chemistry had a positive unstandardized coefficient, this would suggest that these students were likely to be more confident in their math transfer ability than those students taking other classes. Finally, this analysis revealed that retaking the previous math class negatively impacted confidence; however, feelings of a previous math class preparing one for the current science course positively impacted confidence scores.

The analysis revealing that the 18-22 year old group had a lower confidence score was very interesting. Most of the students in this age range have just graduated from high school in which they would have been expected to have more familiarity with mathematics and science than their older counterparts (many of whom had been out of high school and had not exercised these math skills in over 10 years). Many of the older counterparts may had been out of school longer, had families along with other responsibilities. Due to the many responsibilities older students are likely to have, one would expect them to score lower than students just coming out of high school with fewer responsibilities, but that was not the case in this study nor the other studies in Chapter II that examined age. Johnson (1996) revealed that in entry-level college mathematics, age had a positive correlation with mathematical success. Kasworm and Pike (1994) also found similar results. Kasworm and Pike found that even though older students come to school with several disadvantages they still outperform the younger students in college grade point average. In fact, the Kasworm and Pike study goes further in their findings revealing that even though older students had lower high school grade point averages and lower ACT scores they still had significantly higher college grade point averages than younger students.

Given the results of the present study and those found in the literature, the researcher has concluded that older students not only have higher confidence in their ability to transfer math skills, but they also outperform their younger peers, who given the circumstances should outperform their older students. The researcher also believes this result is due in part to a number of possibilities.

It is the opinion of the researcher that one possible explanation for the finding in the present study is that many of the older students graduated from high school before the era of high stakes testing as similarly revealed in the Schwartz et al. (2005) study. Many of these older students were taught mathematics and science by teachers who were not limited to the material that was on a standardized test. In other words, those teachers were allowed to use their experience and teach students the best way they knew students would understand mathematics and science. Students who were in the 18-22 age group have been taught mathematics and science under a system in which teachers are pressured to teach only those things that were state tested in a manner that was most effective for test taking. Unfortunately, this manner appeared to have the effect of lowering the students' confidence in transferring basic mathematical skills.

Another possibility for this result, in the researcher's opinion, could rest in the fact that the older students and younger students tend to have different goals in terms of their education at a community college. Many of the older students come to the community college because they may have been laid off, quit their jobs, or are trying to make a better living for themselves and their families. Most of these students have experienced many hardships in life and appreciate the value of an education and see their education as a means to a better career and living. Therefore, when they come to the community college and take classes, they tend to be very serious about their education and comprehending the material. On the other hand, many of the younger students have not experienced as much hardship as their older counterparts and do not value or see the benefits of an education as much as the older students whom have been out of school longer.

It is highly likely the above rationale is why this study as well as the others mentioned in the literature suggests that older students are better in mathematics and science than their younger counterparts. This finding indicates that teaching method, while it plays a role, does not play as much of a role in confidence in transfer or even achievement, as the willingness, hard work, maturity, and dedication that the student has to take their own education seriously. Consequently, because of the implications this finding may have on reforming education, more research needs to be done on this topic. At this point, the present study as well as the previous studies discussed, indicate that older students simply do much better than younger students when the younger students have the clear advantage.

2. There was a significant effect on the overall mean confidence score based on the science class. It was revealed in this analysis that there was significance between physics (both algebra and calculus based) and physical science and physics had the higher mean score. This analysis indicated that the students taking physics courses had the highest confidence in their ability to transfer their math skills to science courses.

The community college in which this study was conducted requires students taking the algebra-based physics course to have taken and passed college algebra as well as trigonometry or they must have passed college algebra and be enrolled in trigonometry at the time they sign up for the algebra-based physics course. Students taking the calculus based physics course must have passed calculus or currently taking calculus when they enrolled in the calculus based physics class. Because of these math requirements, some might believe that the students taking the physics courses would naturally have higher confidence because they have had more mathematics classes. However, such a conclusion is very misleading. The regression analysis accounted for 37% of the variance in these confidence scores and the previous math class taken was not significant. Furthermore, even ignoring the fact that the regression analysis revealed no significance with previous math class taken, the above rationale does not explain why students taking principles of chemistry had higher confidence scores than chemistry I or chemistry II. Chemistry I and chemistry II have a higher math prerequisite than principals of chemistry. In fact, many of the students taking principals of chemistry are non STEM majors or they have failed chemistry I. Therefore, one can not conclude that students who have had more mathematics will necessarily have higher confidence scores than those with lower math background when it comes to transferring basic math skills, there is a better explanation for this finding.

The more likely explanation for this finding is due to the nature of the physics and chemistry classes; more specifically, how they are taught and how students learn in these classes, which will be addressed in the discussion section.

3. There was a significant difference between the groups for math skills based on confidence score. This repeated measures analysis indicated a significance difference between the math skills. This analysis suggested that students had the least confidence in logarithms and the highest confidence in algebraic operations.

This finding indicated that students have the least confidence in logarithms and slopes, but they are highly confident in algebraic operations. As shown in Table 5 and analyzing the mean and standard deviation for logarithms, it was revealed that 68% of the students who took this survey fell within the range of somewhat disagreeing to somewhat agreeing that they were confident in their ability to transfer logarithmic skills to physics and chemistry. Essentially, this study had revealed that the vast majority of students who took this survey are not very confident they could transfer logarithmic skills to chemistry and physics. One reason for this lack of confidence is how often those math skills are used in physics and chemistry, or even taught in mathematics. Students are not exposed to logarithms as much as they are some of the other basic math skills that were rated higher such as conversions or ratios.

Similarly, the students had the next to lowest confidence in slopes. From Table 8, it is shown that slope has a similar variance and mean confidence score as logarithms; therefore, the researcher has found that 68% of students are unsure of how to transfer the concept of slope to chemistry and physics. Because physics related applications were found to have a higher mean confidence than chemistry, it is likely that most physics students are found at a standard deviation above the mean, while most chemistry students can be found at a standard deviation below the mean (since they have lower confidence scores and chemistry related applications had lower confidence scores). Those results indicate the same conclusion as that given for logarithms, in chemistry logarithmic mathematics skills are not used as much as the other mathematics skills with higher confidence scores.

4. There was a significant difference between the midterm grade groups. This analysis indicated that students who reported a high midterm grade had a higher level of confidence to transfer basic math skills to science than the students who reported lower midterm grades.

This result would be expected because students who reported a high midterm grade would be expected to report a high confidence score. Nevertheless, this finding does indicate that the difference in confidence mean scores between students who reported a higher midterm grade and lower midterm grade is significant. However, the interesting result in this analysis was not that the A and B students had a higher mean confidence average than the students who reported D's and F's, but the fact that the A and B students' scores were not statistically significantly different than the confidence scores by the students who reported have a C as a midterm grade. Furthermore, the students who reported a grade of C have a confidence mean that is not only statistically insignificant from the A and B students but the confidence score reported by the C students is at most different by less than 10%. This finding suggests that there is no statistically significant difference in confidence to transfer basic math skills to physic and chemistry for A, B, or C students. Therefore, a C student taking a science class is likely to have the same level of confidence in transferring their math skills to chemistry and physics as the A student. This conclusion is very similar to the one regarding age. In essence, the C student can be assured that the A and B students do not have a statically significant higher confidence level in their math transfer ability. It also indicates that the C students' achievement may not be lower than the A or B student because of lower confidence. The C student may have a lower grade because of the same rationale of the younger students who performed worse than older students in achievement and confidence discussed earlier.

The same rationale can not be applied to the students who reported midterm grades of D and F, as they were statically significantly lower than the A and B students.

5. There was a significant difference between the groups for science related applications. This analysis suggests that students had higher confidence in their ability to transfer basic math skills to physical science or principals of chemistry problems than chemistry of physics. Also, it was revealed that students were more confident in transferring basic math skills to the physics problems than the chemistry problems.

As elaborated on earlier in conclusion 2, the reason students performed the lowest in the chemistry applications group is likely due to the nature of how chemistry and physics courses are taught which will be discussed in more detail in the discussion section.

Discussion

The results from this study have given rise to revelations about the students' confidence in their ability to transfer mathematics to science. One of the statistical analyses from this study has revealed that students had the lowest confidence in using logarithmic mathematics skills in science courses, but report the highest confidence in using algebraic operations in science courses. This may result from the frequencies in which these math skills are used in physics and chemistry. Students taking physics do not use logarithmic math skills as often as they do algebraic expressions. In most physics problems the students are looking for a variable that missing, requiring algebraic manipulation to isolate and solve for the unknown. The same is generally true for chemistry as well. The use of logarithms in chemistry is commonly used in acid base problems. In physics, students use logarithms when they are working problems that involve sound as well as RC (resistor and capacitance) or RLC (resistor, inductor, and capacitance) circuits. Unfortunately, most of those topics are taught in physics II and that class was not offered when this study took place. Slope is used more often in both courses, particularly the lab sections. Slope may be rated with low confidence because most of the work can be done on a graphing calculator, thus eliminating the need for conceptual understanding of slope.

This finding is very useful for designing a STEM (science, technology, engineering, and mathematics) summer enrichment or high school to college bridge program. Math and Science educators designing such programs for students entering college should include in the curriculum a review of slope and logarithmic math skills. This study indicates that of all the basic math skills needed for introductory science courses, students have the lowest transfer confidence in these two math skills. Furthermore, as shown in the literature review, those topics should be taught to address any misconceptions the students have in regards to those math skills from a constructivist approach. These students may lack confidence in logarithmic skills because they may not be emphasized as heavily on state tests as the other math skills; therefore, math teachers teaching Algebra 1 (the state tested subject in Mississippi required for graduation) may not put much emphasis on this when it is taught in class. Because the two math skills may not have been taught with much emphasis in high school, the bridge or summer enrichment program should not only have refreshers in logarithms and slopes but it should also teach students how to transfer those skills to physics and chemistry.

Another finding revealed by the statistical analysis in this study was that students taking physics had higher confidence scores than those taking chemistry and students reported higher confidence in transferring mathematics to physics than chemistry. Based on this study and the literature available, the researcher will discuss the possibilities for why those results were found.

One reason for this statistic may rest in the nature of the two subjects and how they are taught. Many mathematics courses use matters in physics to explain certain mathematical concepts (e.g. using instantaneous speed to explain the derivative in calculus) or using speed to explain slopes. Perhaps students feel more comfortable transferring mathematical skills to physics problems than chemistry problems because they have seen more physics related applications in previous math courses. Also, this statistic may be explained by the fact that most topics in physics involve utilizing mathematical skills more frequently and in depth than those in chemistry.

The nature of physics and chemistry courses are very important in discussing why students scored the lowest in transferring math to chemistry than any of the other sciences. The researcher argues the reason for this is that chemistry is generally taught with more of a behaviorist's teaching style and less of a constructivist's style than physics. The researcher will discuss this further below.

A study done by Potgieter et al., (2008) concluded that the lack of understand of graphing and connecting that to algebra resulted in the poor chemistry performance. The present study indicated that students have the least confidence scores in transferring math skills to chemistry problems (regardless of the math skill considered). The same students reported higher confidence scores for the same math skills in physics related problems. Furthermore, chemistry students reported lower confidence scores than physics students. The results from the present transfer study and Potgieter, Harding, and Engelbrecht reveal that the problem chemistry students have is that the basic math skills are taught in a manner that makes it easier for student to transfer those skills to physics than chemistry.

Because students had much higher confidence in transferring math skills to physics than chemistry for the same math skills, it suggested that the graphing in of itself may not be the problem with the chemistry students as suggested by Potgieter et al. (2008). The true problem may rest in how the graphing skill was transferred specifically to chemistry, because students reported having higher confidence in graphing on physics problems. This finding needs to be investigated more, because if this preliminary analysis holds true, the problem may lie in how chemistry teachers teach.

Since chemistry students have lower confidence levels than physics students, this suggest that many chemistry teachers may be teaching chemistry using more behaviorist methods as opposed to constructivist's methods. As indicated earlier in the literature review, students are more likely to transfer math skills if taught or learned using constructivist methods as opposed to the rote memory methods favored by behaviorists. Many physics problems require the teacher to teach the students physics in a conceptual manner: few college level physics problems can be solved by rote memorization whereas many chemistry problems can be. Therefore, the lower confidence scores reported in chemistry may be due, in part, to their chemistry teachers employing more behaviorist teaching techniques. Behaviorists’ techniques in chemistry are effective for memorizing and solving certain chemistry problems but harm the students' confidence and ability to transfer mathematics as revealed in this and other studies mentioned in Chapter II. Therefore, it is advised that chemistry teachers teach chemistry using the constructivist techniques (teach for conceptual understanding, teach using the students prior knowledge, use inquiry learning techniques, collaborative and/or peer learning approaches, etc.) discussed in Chapter II.

Finally, students who reported they felt their previous math class did not prepare them for the current science course reported lower confidence scores. This statistic indicates that there are students who feel their previous math class did not prepare them for the current science course and as a result they have lower confidence in their ability to transfer basic math skills to physics and chemistry.

Based on this finding, math teachers need to start teach more math skills for conceptual understanding. As shown in Chapter II, doing so can help address misconceptions the student have concerning the basic math skills needed for introductory science classes. The findings of the present transfer study along with the transfer findings in Chapter II indicate to the researcher that students may have misconceptions of some of the basic math skills.

Sanders (2004), Beaubouet (2002), and Basson (2002) note that students had poor math skills. Nashon and Nielsen (2007) found the biggest problem with physics students were application of algebra skills to physics. The present confidence transfer study revealed that student scored the highest confidence in algebra skills. One possible explanation for this phenomenon is that the students have misconceptions regarding these basic math skills. The results from the present study (in which students on average somewhat agreed they could transfer mathematics to science) and those of Sander et. al, indicated that students feel confident they can use transfer these math skills, but do not demonstrate the ability. Having high confidence but lacking ability to transfer is an indication of a possible misconception of the math skill. Therefore, this study found that many problems students have in transferring basic math skills to physics and chemistry courses may be because of misconceptions the students have of basic math skills. Because of that misconception the researcher recommends that math teachers teach mathematics for conceptual understanding to address any future misconceptions students may have when they take a future physics or chemistry course.

It should be noted that the results of high confidence levels but low performance levels noted in the earlier studies imply that not only should mathematics be taught for conceptual understanding, it should be taught with meaning. In order to make mathematics for more meaningful and applicable to physics and chemistry, it is recommended that math and science teachers collaborate more on teaching science and mathematics. Andresen and Libenskov (2009) found when different subject area teachers collaborated in multidisciplinary teaching the students could see how to transfer math between subjects. Due to the low confidence scores found with not only the chemistry students but even the chemistry related problems, it is highly recommended that chemistry and math teachers collaborate on lessons.

In terms of items that were not statistically significant, the regression analysis revealed that the homework method (whether students did their homework online or using the traditional pencil and paper method) had no statistically significant effect on confidence scores. As discussed in Chapter II the research was conflicted on the effect paper based or online homework has on achievement. Research studies indicated that the online homework method has a positive effect on achievement (Gok, 2011; Hirsh &

Weibel, 2003; Mendicino et al., 2009). There were studies that found the paper and pencil method had a positive effect on achievement (Ashby et al., 2011; Demirci, 2007; Macedo-Rouet et al., 2009; Pascarella, 2004; Zerr, 2007). There were studies that revealed there were no major differences in achievement between the two methods (Allain & Williams, 2006; Bonham et al., 2003; Cole & Todd, 2003; Demirci, 2010; Johnston, 2004). The present study conducted by the researcher was the first to examine the effect doing of the homework method (online or traditions) on transferring math skills to science (ability or confidence). The present study revealed that the homework method has no significant effect on the confidence to transfer math skills to physics and chemistry. This finding compliments the previous studies that indicated the homework method had no effect on achievement. This finding suggests to math and science educators that students do not need to necessarily pay the extra fees required to do their homework online because there is no difference (in confidence to transfer or achievement) between this method and doing their homework the traditional method.

Based on this analysis the researcher would recommend that science educators incorporate more mathematics into their curricula, particularly chemistry. The analysis indicated that the math skills students have more exposure to yielded higher confidence scores and those with less exposure (such as logarithmic math skills) yielded lower confidence scores. Furthermore, math educators should incorporate more chemistry and physics applications when they teach mathematics.

Limitations

1. This study was limited to an open admissions community college in central Mississippi with more nontraditional students than those found in a four year university.

2. The study was limited to the truthfulness of what the students reported, therefore the answers were biased to how the students reported them and may not reflect the truth.

3. This study was limited to how confident the students were in their ability to transfer basic math skills to physics and chemistry and not their actual ability to transfer, which is likely to be different.

4. This study was limited to examining confidence towards the end of the first semester and did not include any physics II students. Physics II students have the highest math requirements than any other students participating in the survey and inclusion of these students would allow the researcher to draw more conclusions about the results.

Recommendations for Future Research

1. Perform this study again and ask the students to work out the example problems that came with the instrument. Compare how the students performed on problems with the confidence they reported.

2. The study could be done on the first day the science class begins and repeated on the final day of class. This method should be used with two teachers that have different teaching styles to determine which teaching method increased students' confidence in transfer or (if the students work out the problems) which method actually improved mathematical transfer skills.

3. The chemistry II students reported lower confidence scores than principals of chemistry students. Because of this finding, a study should be done to address if the math skills used in chemistry II are significantly more rigorous than chemistry I. The

mathematical rigor found that the chemistry II (not present in chemistry I) might be why students have lost confidence in their mathematical ability.

4. Since students reported the highest confidence in the algebraic operations math skill and the lowest confidence in the logarithmic skills, a study should be done to address how physics and chemistry instructors can incorporate more logarithmic math skills into their respective classes.

5. Because of the low confidence score for logarithms, a study should be conducted that focuses on effective ways of teaching logarithmic math skills for transfer.

6. A study should be conducted to understand why age makes a difference in the level of confidence students have with transferring math skills.

7. This study should be replicated at the high school (seniors) level and the university level.

8. A study should be conducted to find the effect the ability to transfer basic math skills to science has on a student's final grade/and or grade point average in the sciences.

9. A long term study should be conducted when a student first enters college and another study done after two years and analyzed to determine if two years of taking science and math classes has significantly improved their ability or confidence in their ability to transfer basic mathematics skills to science.

10. Expand this study to higher level science courses with higher level mathematics skills.

11. Regression analysis predicts the 18-22 year old student who retook their previous math course will have the lower confidence scores that the average college student taking an introductory science course. A study should be conducted analyzing

the social and cognitive factors within age and retaking a math course that effect confidence in transferring mathematical skills.

12. Because students who reported retaking their previous math class reported lower confidence scores, a study should be conducted examining if their possible lack of achievement in science in part due to their lack of confidence to transfer their math skills (that might negatively impact actual ability) to science classes or lack of mathematical knowledge (unlikely since they had to pass the math class to meet the perquisite for the current science course).

13. The Pascarella (2004) study indicated that the online homework method had a negative effect on Physics students to comprehend physics problems beyond basic memorization and guessing techniques. Because the present study revealed no statistical significant difference in homework method on confidence, the researcher recommends conducting a more detailed study on the effect (if any) the homework method has on the student's ability to transfer math skills in Chemistry. Similarly, an identical study should be done for Physics. Results from such a study may reveal any misconceptions; or the lack thereof, that the online homework method has in promoting difficulties the students have in math transfer abilities. Because online homework methods are gaining popularity in community college as well as university math and science courses, the study suggested by the researcher may reveal surprising results.

Recommendations for Policy and Practice

1. Based on the result indicating that the students had the lowest confidence in logarithmic math skills, the researcher recommends that math and science educators stress more conceptual understanding of logarithmic mathematics skills.

2. As students who did not feel their previous math class prepared them for the current science class, the researcher recommends that mathematics and science educators collaborate when developing lessons.

3. Because the 18-22 age group revealed significance with a negative effect on confidence score, the researcher recommends that mathematics and science educators develop strategies that are relevant to this age group and will help them develop confidence in their mathematics transfer skills.

4. Because students scored higher with transferring mathematics to physics related applications, the researcher recommends that chemistry educators find ways of incorporating more mathematics in their course. Also the researcher recommends that Math educators incorporate more chemistry related problems in their mathematics courses.

5. Because students who retook their previous math course had significant lower confidence scores, the research recommends that science and mathematics educators offers more remediation services in which these students can help with basic math skills to develop their confidence when they have to transfer those math skills to their science courses.

APPENDIX A

TRANSFER BASIC MATH SKILLS TO PHYSICS AND CHEMISTRY

This survey is designed to measure your confidence in applying math skills that you have learned in the past to physics or chemistry. Confidence as it relates to this survey is the certainty in your ability to do something. In other words, how certain are you that you can do perform the tasks being asked in items 1-30. This is a research study with the goal of statistically analyzing what areas of mathematics students have the most and least confidence in. It is my goal to determine those math skills that are the most and least troublesome for students (in terms of confidence). This questionnaire should take between 20-30 minutes. Your participation is completely voluntary and you may discontinue participation without penalty or prejudice to you. You may choose to not answer any questions that make you uncomfortable. By completing this survey, you are choosing to participate in the study. You are free to ask your instructor any questions you may have. Question regarding research should be directed to Mr. Quinn (601-857-3641).

This project has been reviewed by the Human Subjects Protection Review Committee, which ensures that research projects involving human subjects follow federal regulations. Any questions or concerns about rights as a research subject should be directed to the chair of the Institutional Review Board, The University of Southern Mississippi, 118 College Drive #5147, Hattiesburg, MS
39406-0001, (601) 266-6820.

Please answer the following questions to the best of your ability. Your responses to this survey will remain anonymous.

For items 1- 30, please rate your level of confidence on a scale of 1-4 or Irrelevant using the following rubric. *Please refer to the attachment labeled* "**Examples**" to get an idea of what is meant by the following questions.

1 = completely disagree: "I am not at all confident that I could do this".

2= somewhat disagree: "I might not be able to do this".

3= somewhat agree: "I might be able to do this".

4= completely agree: "I am confident that I could do this".

IR= irrelevant: "This concept has nothing to do with my science course".

1) I can graph the slope of a line.

1 2 3 4 IR

2) I can graph the slope of a line to show the rate of a chemical reaction.

1 2 3 4 IR

3) I can graph the slope of a line to show the rate of distance covered with time.

1 2 3 4 IR

4) I can use “rise over run” to find a rate.

1 2 3 4 IR

5) I can use “rise over run” to determine how long it may take a chemical reaction to reach equilibrium.

1 2 3 4 IR

6) I can use “rise over run” to determine how velocity changes.

1 2 3 4 IR

7) I can simplify complex fractions.

1 2 3 4 IR

8) I can do conversions using moles .

1 2 3 4 IR

9) I can convert from kilometers per hour (km/hr) to meters per second (m/s) when given the conversion factor(s).

1 2 3 4 IR

10) I can convert kilometers to meters (km to m) when given the conversion factor.

1 2 3 4 IR

11) I can solve an equation with one unknown variable.

1 2 3 4 IR

12) I can balance a chemical equation.

1 2 3 4 IR

13) I can solve for either density, mass, or volume if any two of the three variables are given.

1 2 3 4 IR

14) I understand how to express numbers in powers of 10.

1 2 3 4 IR

15) I can use a shorthand method of writing the size of a Ca atom using powers of 10 when given the entire measurement.

1 2 3 4 IR

16) I can use a shorthand method of writing the size of the earth's radius using powers of 10 when given the entire earth's radius in meters,

1 2 3 4 IR

17) I can show how units cancel to give the correct units for volume when given density and mass.

1 2 3 4 IR

18) I can add positive and negative integers.

1 2 3 4 IR

19) I can calculate the net charge on a chemical compound when given the necessary information.

1 2 3 4 IR

20) I can find the resultant when given the proper vectors.

1 2 3 4 IR

21) I can solve the following problem: Bill walks 2 miles north, then 5 miles south. What is his net result?

1 2 3 4 IR

22) I can recognize and graph the y intercept if given the necessary information to do so.

1 2 3 4 IR

23) I can look at a graph of the rate of a chemical reaction and recognize the amount of substance at 0 seconds.

1 2 3 4 IR

24) I can look at a graph of position versus time and recognize what the initial distance was at 0 seconds.

1 2 3 4 IR

25) I can find the slope of a continuous function at some defined point.

1 2 3 4 IR

26) I can find the rate of a chemical reaction if a catalyst is added to the system at a defined time.

1 2 3 4 IR

27) I can find the slope of the velocity time curve at a defined time when an object undergoes acceleration.

1 2 3 4 IR

28) I can easily solve logarithmic functions involving x.

1 2 3 4 IR

29) I can solve the pH of an acid or base given the needed measurements.

1 2 3 4 IR

30) I can solve problems involving sound levels using the decibel scale.

1 2 3 4 IR

31) Are there any math skills that you struggle with in this science class? If so, please list them

32) What are some things that you think math teachers could do to better prepare you for the math involved in this science class?

Please answer the following questions to the best of your ability. Your responses to this survey will remain anonymous.

33) Please select your age range

a.) 18-22 b.) 23-27 c.) 28-32 d.) 33 and over

34) What is your gender?

a.) Male b.) female

35) Please select the appropriate degree obtained

a.) High School Diploma b.) GED c.) Associate's Degree d.) Bachelor’s Degree or higher

36) Please select your current enrollment status.

a.) Full time b.) Part time

37) What was the first math class you took in college?

a.) Calculus b.) Trigonometry c.) College Algebra d.) Intermediate Algebra

e.) Beginning Algebra f.) Fundamentals of Mathematics

38) How was homework done in the math course you took prior to this science course?

a.) pencil and paper b.) online c.) combination of online and pencil/paper

39) Which science class are you currently taking (lecture not lab)?

a.) Physical Science b.) Physics (calculus-based) c.) Physics (algebra-based) d.) Chemistry e.) Principles of Chemistry f.) Physics II (algebra-based)

g.) Physics II(calc-based) h.) Chemistry II

40) What was your grade in your previous math class?

a.) A b.) B c.) C d.) D e.) F

41) Did you retake your previous math class?

a.) yes b.) no

42) Are you retaking this science class (lecture not lab)?

a.) yes b.) no

43) What is your midterm grade in this science class (lecture not lab)?

a.) A (90-100) b.) B (80-89) c.) C (70-79) d.) D (60-69) e.) F(59 & below)

44) How many hours per week do you use to study for this class at home (lecture not lab)?

a.) 0-3 hrs b.) 4-7 hrs c.)8-11hrs d.) 11 or more hours

45) I feel as though my previous math class has prepared me for this science class.

a.)yes b.) no

46) I feel as though my previous math class focused too much on theory and not enough application to science.

a.)yes b.) no

Examples

1. Graph the line y=5x+10 using slope and y intercept

2. Using the equation aA+bB -> cC +dD
where the lower case letters (i.e. a) represent the coefficient of the balanced equation and the upper case letters (i.e. A) represent the molecule. Compute then graph the rate of reaction (taken from UC Davis)

3. A car starts at 2 meters, then travels 5 meters for one second, 10 meters for 2 seconds, 15 meters for 3 seconds. Graph the rate.

4. Using the graph produced in #1, use "rise over run" to find the slope.

5. Using the graph produced in #2, given the initial and final concentration amounts, use 'rise over run', determine how long it will take the reaction to reach equilibrium.

6. Given the following: initial speed is 10 m/s and the final speed is 5 m/s and it happens in 10 seconds, graph this motion and use 'rise over run' to find the acceleration.

7. Simplify (5/6)/(8/9)

8. How many pennies are in a mole of pennies? How many thousand-dollar bills (k-notes!) is that mole of pennies equal to?
(taken from UC Davis)

9. Convert 5 km/hr to m/s, using the following conversion factors: 3600sec=1hr, 1km=1,000m

10. Convert 5 km to m, using 1km=1,000m

11. If c=18 and d=4 Solve for x: 5x=10c-17d

12. Hydrochloric acid reacts with a solid chunk of aluminum to produce hydrogen gas and aluminum ions. Write the balanced chemical equation for this reaction.
(taken from UC Davis)

13. Solve for volume, given the density is 5(g/cm^3) and the mass is 25 g (density is mass/volume).

14. Express the national debt of $15,000,000,000,000 in terms of powers of ten.

15. The size of the Ca atom is 100 picometers, there are 1,000,000,000,000 picometers in a meter. Express the unit of the size of the Ca atom in meters and the numerical value in scientific notation. (from UC Davis)

16. The radius of the earth is 6,384 km, put this number in unit of meters and the numerical value in scientific notation.

17. The units for density is g/cm^3 and the unit for mass is g. Show, using the density equation (given in #13) that the volume has units of cm^3.

18. 5 + (-25) = ________

19. Knowing that electrons have a negative charge. What is the net charge of a neutral atom that has lost 2 electrons? What is the net charge of a neutral atom after it is gained two electrons?

20. Justin Beiber walks east 2 miles then walks west for 5 miles. Using east as "+" and west as "-". Solving algebraically, what's the numerical answer and does this result have a "+" or a "-" sign?

22. Determine the y intercept and graph the following line: $5y=2x+10$

23. Looking at the graph produced from #2, determine what the amount of substance at 0 seconds.

24. Looking at the graph produced in #3, determine the distance at 0 seconds.

25. $f(x)=5x^3+2x^2$, find the slope at x=5.

26. Using the proper mathematical techniques, the equation for this graph is represented by $A(t)=7.89x10^{-5}t^4+6.022x10^{23}$. Where A represents the reactant or the product and t represents the time (in seconds). Find the rate of this chemical reaction at 5 seconds?

27. A velocity versus time graph produces the following equation: $v(t)=6t^3+35$, where v is velocity (in m/s) and t is time (in seconds). Find the value acceleration at 10 seconds?

28. Solve $15 = 8 \ln(3x) + 7$. (from University of Colorado).

29. Use the pH equation $pH=-\log[H_3O^+]$ and pKw equation $pKw = pH + pOH = 14$ to solve the following problem. A solution is 0.00025 M HCl. What is the pH and pOH of this solution?

30. Knowing that sound level is measured by L= 10 log(I1 / I0), where I_1 is the sound intensity of the object and I_0 is the intensity of sound of the threshold of human hearing, solve the following problem:

With one violin playing, the sound level at a certain place is measured as 50 dB. If four violins play equally loudly, what will the sound level most likely be at this place? (from Indiana University)

APPENDIX B

IRB APPROVAL

THE UNIVERSITY OF
SOUTHERN MISSISSIPPI

INSTITUTIONAL REVIEW BOARD
118 College Drive #5147 | Hattiesburg, MS 39406-0001
Phone: 601.266.6820 | Fax: 601.266.4377 | www.usm.edu/irb

NOTICE OF COMMITTEE ACTION

The project has been reviewed by The University of Southern Mississippi Institutional Review Board in accordance with Federal Drug Administration regulations (21 CFR 26, 111), Department of Health and Human Services (45 CFR Part 46), and university guidelines to ensure adherence to the following criteria:

- The risks to subjects are minimized.
- The risks to subjects are reasonable in relation to the anticipated benefits.
- The selection of subjects is equitable.
- Informed consent is adequate and appropriately documented.
- Where appropriate, the research plan makes adequate provisions for monitoring the data collected to ensure the safety of the subjects.
- Where appropriate, there are adequate provisions to protect the privacy of subjects and to maintain the confidentiality of all data.
- Appropriate additional safeguards have been included to protect vulnerable subjects.
- Any unanticipated, serious, or continuing problems encountered regarding risks to subjects must be reported immediately, but not later than 10 days following the event. This should be reported to the IRB Office via the "Adverse Effect Report Form".
- If approved, the maximum period of approval is limited to twelve months.
  Projects that exceed this period must submit an application for renewal or continuation.

PROTOCOL NUMBER: **12091808**
PROJECT TITLE: **Students' Confidence in the Ability to Transfer Basic Math Skills in Introductory Physics and Chemistry Courses at a Community College**
PROJECT TYPE: **Dissertation**
RESEARCHER/S: **Reginald Quinn**
COLLEGE/DIVISION: **College of Science & Technology**
DEPARTMENT: **Center for Science and Math Education**
FUNDING AGENCY: **N/A**
IRB COMMITTEE ACTION: **Expedited Review Approval**
PERIOD OF PROJECT APPROVAL: **10/10/2012 to 10/09/2013**

Lawrence A. Hosman, Ph.D.
Institutional Review Board Chair

APPENDIX C

INSTITUTION RESEARCH APPROVAL

HINDS COMMUNITY COLLEGE
P.O. Box 1100 • Raymond, Mississippi 39154-1100
601.857.3240 • Fax: 601.857.3518

OFFICE OF THE PRESIDENT

August 8, 2012

Mr. Reginald Quinn
PO Box 1526
Raymond, MS 39154

Dear Mr. Quinn:

I am hereby approving your letter of request to conduct your PhD study at Hinds Community College. I understand this will involve analyzing students' application of math skills as it relates to Physics and Chemistry classes on the Raymond Campus.

Please contact Dr. Theresa Hamilton, Vice President for the Raymond Campus and Jackson Campus – Nursing Allied Health Center and director of College Parallel Programs at 601-857-3250 to coordinate with you your study.

Sincerely,

Clyde Muse

Clyde Muse
President

CM:lp

Raymond Campus • Utica Campus • Jackson Campus • Rankin Campus • Vicksburg-Warren Campus
http://www.hindscc.edu

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