1-1-2013

Effect Of Personalized Instruction On The Achievement Of Solving Mathematical Word Problems

Danica Vukmirovic
Wayne State University,

THE EFFECT OF INDIVIDUAL PERSONALIZATION ON SOLVING MATHEMATICAL WORD PROBLEMS

by

DANICA VUKMIROVIC

DISSERTATION

Submitted to the Graduate School

of Wayne State University,

Detroit, Michigan

in partial fulfillment of the requirements

for the degree of

DOCTOR OF PHILOSOPHY

2013

MAJOR: INSTRUCTIONAL TECHNOLOGY

Approved by:

____
Advisor Date

____

____

____

____

DEDICATION

I dedicate this dissertation to my most honorable, loving, and supportive family: my parents, Milan and Smilja Vukmirovic and my most beautiful sister Milica who supported, encouraged, and loved me. You were the best teachers and you will forever live in our hearts. Vjecna ja Pamjat.

I also dedicate this dissertation to my most wonderful and loving daughter and son, Sava and George (Djordje) – you are made of stars. I have always been, and always will be, so proud of you both. I am the luckiest mom in the world.

Ecclesiastes 3

To every *thing there* is a season, and a time to every purpose under the heaven:
A time to be born, and a time to die: a time to plant, and a time to pluck up *that which* is planted;
A time to kill, and a time to heal; a time to break down, and a time to build up;
A time to weep, and a time to laugh; a time to mourn, and a time to dance;
A time to cast away stones, and a time to gather stones together; a time to embrace, and a time to refrain from embracing;
A time to get, and a time to lose; a time to keep, and a time to cast away;
A time to rend, and a time to sew; a time to keep silence, and a time to speak;
A time to love, and a time to hate; a time of war, and a time of peace.

I know that, whatsoever God doeth, it shall be for ever: nothing can put to it, nor any thing taken from it; and God doeth *it,* that *men* should fear before him.
That which hath been is now; and that which is to be hath already been; and God requireth that which is past.
(That which is, already has been. And that which will be, has already been. For God allows the same things to happen again.)

ACKNOWLEDGEMENTS

I would like to express my sincere gratitude for the guidance and support of my adviser, Dr. Monica W. Tracey. My sincere thanks extend to my dissertation committee members, Dr. Timothy Spannaus, Dr. James Moseley, and Dr. Sarunas Mingela for all the ongoing support, invaluable feedback, and time. I appreciate the help and encouragement provided to me by the late Dr. Gail Fahoome, Dr. Gary Morrison, Dr. Ingrid Guerra-Lopez, Veronica Bielat, Michele Norris and Paul Johnson. I sincerely appreciate all the support that was given to me by the Georgian College community especially by Professor Kelly Halliday, Professor Nathalie, Sandra Kurt, Debbie-Jane Stansfield, Dean Bonicalzi and to all my colleagues and friends in the Automotive Business School of Canada.

Thank you to my friends and their families who supported and believed in me on this journey - lifting me up in love and friendship when I needed it most; Rosanne Piscitelli, Zora Cvetkovski-Injic, Lily Maceyovski, Caroline Gilson, Dolores Nowak and Cindy Lynde-Perry.

I would like to thank the church community of St. John Orthodox Church, especially Rev. Fr. Constantine Katsilas and Matushka Pat, Lorraine, and Kim for their kindness and support during difficult times.

God grant you all many years.

TABLE OF CONTENTS

LIST OF TABLES

CHAPTER 1: INTRODUCTION

A nation's success in the global knowledge-based economy is dependent upon the ready supply of highly skilled and educated individuals. These knowledgeable individuals, who are typically college graduates, are often referred to as human capital and participate in knowledge-based economies that utilize technology to produce, distribute, and use knowledge and information (Organization for Economic Co-Operation and Development [OECD], 1996). The consequences for a nation that cannot meet the increasing global demands for an educated work force would negatively affect global economic competitive standing and the well-being of its citizens.

The Adult Literacy and Life Skills Survey (ALL), conducted by the Organization for Economic Co-operation and Development (OECD), was used to assess skill proficiency of adults in countries including Canada, in domains of literacy, problem solving, and numeracy (mathematics) required to participate in a competitive global marketplace. Findings of the study indicated that there is a strong positive association between skills and educational attainment. In other words, more years of schooling consistently demonstrated higher skill proficiency (OECD, 2005). Supporting research also indicated that educational attainment is a key determinant of cognitive skills proficiency which includes adult literacy and numeracy (Kirsch, Jungeblut, Jenkins, & Kolstad, 2002). More than half of the adult population in Canada scored below the level considered by experts as a suitable minimum level for coping with the increasing demands of the emerging knowledge society and information economy for document literacy, numeracy and problem solving domains (OECD, 2005).

Statement of the Problem

Graduation rates are negatively affected by college learners' inability to demonstrate proficiency in mathematics. Remedial or developmental mathematics courses have been used to enhance learner math achievement but the completion rate of these courses are dismal. A challenge for learners at all levels is solving mathematical word problems. Previous studies examining the effect of personalization of instruction indicated positive results on learner achievement in elementary and secondary levels (Anand & Ross, 1987; Hart, 1996; Harter & Ku, 2007; Ku & Sullivan, 2002; Lopez & Sullivan, 1991, 1992). However, no such studies regarding personalization of instruction have taken place at the college level. This study examined the effect of personalization on learners' achievement and motivation towards solving mathematical word problems.

Ongoing global technological advances require knowledge in mathematics particularly in problem solving to succeed in the global economy (Middleton & Spanias, 1999). Educational experts, business leaders, and politicians in Canada have expressed concern about the educational attainment trends that limit the supply of college graduates with sufficient mathematical knowledge and skills needed to drive future economic growth in a highly competitive global marketplace.

During the period of 1970 to 1998, demand for college-educated workers increased due to the adoption of computer based technologies. The integration of computer technology in the workplace replaced those workers involved with routine tasks, which resulted in a lower demand for these workers. Non-routine tasks that computer technology could not perform required workers who were skilled in complex communications, problem solving, creativity, and flexibility. Demands for these highly skilled workers who were typically college-educated increased (Autor, Levy, & Murnane, 2003).

Educational achievement, more than cognitive skill, determines labor force outcomes such as occupational status and earnings (Kerckhoff, Raudenbush, & Glennie, 2001). As such, the demand for a highly skilled and educated workforce continues today. Canadian labor force projections for 2015 are expected to grow by 1.9 million people and more than two-thirds of new jobs will require postsecondary education.

Further evidence to the demand of Canadian college-educated workers can be seen in unemployment, employment, and wage gaps between college graduates and high school graduates. Reported unemployment rates were inversely related with education achievement levels; that is, unemployment rates were lower for those with higher educational achievements. Canadian employment rates for those with tertiary education were fairly stable during the time period 1999-2009. Approximately 80 percent of adults aged 25 to 64 years with tertiary education were employed while only 55 percent of those with less than high school were employed (OECD, 2010).

Wage gaps also exist between the most educated and the least educated in the Canadian labor force. Almost one-third of tertiary educated adults aged 25-64 earned more than two times the median income while more than one-third of those without a high school diploma earned less than half of the median income (Miller, Sen, Malley, & Burns, 2009).

Preparing citizens for a knowledge-based economy is needed to maintain competitiveness, prosperity and security. Dalton McGuinty, Premier of Ontario, in a 2005 address regarding postsecondary education, stated "In today's knowledge-based economy, the best jobs and the most investment will go to the places with the best-educated, most highly skilled people" (Office of the Premier, 2005, para. 20).

Educational attainment trends have also been identified as a challenge in providing a qualified workforce. Canada ranked second amongst the Group of Eight (G8) industrialized nations (United States, Canada, France, Germany, Italy, Japan, the Russian Federation and the United Kingdom) in a 2009 study by the National Center for Education Statistics (NCES) in which tertiary levels of education attainment by 25-64 year-olds was compared. Tertiary education includes vocational higher education, academic higher education below a doctoral level, and doctoral level of higher education. Less than half of the Canadian workforce achieved tertiary education while the Russian Federation workforce achieved the highest rank with more than half of the workforce achieving tertiary education (Miller et al., 2009).

A report by the OECD (2010), *Education at a Glance 2010,* compared the percentage of postsecondary attainment in 2008 for cohort groups 25-34 years old and 55-64 years. The younger cohort represented those individuals who will replace the older cohort which traditionally would be considered first to exit the labor market. The average OECD educational attainment of 25-34 year olds was greater than for the group of 55-64 year olds. This trend, indicating a workforce transitioning to a more educated group, holds true for Canada as well. Canada has the second highest postsecondary attainment by 25-34 year olds when compared to the other OECD and OECD partner countries. South Korea had the greatest difference in education between age groups. There was a 44 percent difference between the oldest to the youngest groups, indicating that the older and less educated workforce would eventually be replaced by the younger and significantly more educated workforce. This indicated South Korea was in a greater competitive position in the global knowledge-based economy. Data for the United States indicated that 42 percent of 25-34 year olds achieved post-secondary education compared to 40 percent of 55-64 year olds (OECD, 2010). The younger workforce educational attainment is only slightly greater than the older workforce and is reflected in the stagnant U.S. college graduation rates (Aud et al., 2011).

Canadian graduation rates for tertiary education have increased steadily from 1995 to 2008 which is reflected in the 2.5 percent average growth rate of tertiary education attainment for the 25-64 year-old-population. The 2008 college graduation rate in Canada was reported to be more than twice the OECD graduation rate of 10 percent. As college graduation growth rates have a direct impact on the availability of a higher level educated workforce needed to compete globally with other nations, Canadian college graduation rates must continue to grow in order to meet the competitive global demand for knowledge workers (OECD, 2010).

Many issues such as personal, financial, and academic performance affect college graduation rates. Many students must take remedial or developmental courses because they are ill-prepared for college level work. Remedial courses are usually offered in mathematics, writing, English, reading and study skills and typically must be completed in order to continue in an academic program. Remedial or developmental courses are intended to improve basic skills and knowledge as well as to develop study and social habits that are required for academic success at college (Aud et al., 2011).

According to Lazarick (1997), more students required developmental mathematics than any other development course. The intent of remedial programs is to prepare students to be successful in the college curriculum (Bahr, 2008). Remediation leads to educational attainment which is a principal determinant of socioeconomic outcomes.

According to Bahr (2008), math remediation programs were highly effective in resolving skill deficiencies. Findings indicated that those students who achieved college-level math skills through remediation had similar academic attainments such as credential completion to those students who did not enroll in remedial math coursework. As Bahr (2008) stated, "it is exceedingly apparent in light of this analysis that identifying methods of increasing the rate of successful remediation in math should be a topic of central concern to all stakeholders in the community college system"(p. 446).

In the province of Ontario, over 30 percent of all first year college learners achieved a grade of 50 percent or less in a first year college mathematics course during 2011. As a result of poor mathematical grades, these learners are described as at risk of not completing their chosen college programs. Furthermore, over 20 percent of first year college learners enroll in remedial and foundational mathematics courses (Orpwood, Schollen, Leek, Marinelli-Henriques, & Assiri, 2012).

One of the most significant elements of mathematics, solving mathematical word problems, is considered a challenge by students (Cakir, Simsek, & Tezcan, 2009; Hart, 1996). Mathematical problem solving is a crucial and fundamental skill required in areas of health, industry, and technology (Levin & Belfield, 2009; Kirsch, Braun & Yamamoto, 2007). Since instruction has been identified as the most important contributor to the success of developmental students (Boylan, 2002), and motivation has been positively related to student learning (Frymier, 1994), effective strategies to increase the achievement and motivation of students enrolled in developmental math must be explored. Ma (1997) recommended increasing student motivation by connecting to students' interests in order to increase perceived relevance of mathematics. Personalization, an instructional strategy that imbeds personal information and interests, was found to be effective in improving problem-solving skills of students (Anand & Ross, 1987; Hart, 1996; Harter & Ku, 2007; Ku & Sullivan, 2002; Lopez & Sullivan, 1991, 1992).

Purpose and Research Questions

The purpose of this research study was to determine the effect of individual personalized mathematical instruction on the achievement of solving mathematical word problems by undergraduates enrolled in postsecondary developmental mathematics course. The study was also conducted to determine the effect of individual personalized mathematical instruction on undergraduate motivation to solve mathematical word problems.

The study was guided by the following research questions:

1. What is the effect of individual personalization on learner mathematical knowledge acquisition?
2. What is the effect of individual personalization on learner motivation to solve word problems?
3. What is the effect of individual personalization on long term learner motivation?

Definition of Terms

ARCS model. The ARCS Model describes four categories of motivational concepts which are attention, relevance, confidence, and satisfaction. The attention category addresses the interest of learners and the stimulation of curiosity to learn. Relevance refers to the personal needs and goals of the learner that create an attitude that is positive. Confidence helps the learner to believe that success is possible and that the learner can control their success. Satisfaction deals with the reinforcement of accomplishments using both internal and external rewards (Keller, 2010).

Cognitive information processing. Cognitive Information Processing describe how humans process information received from the environment using internal processes much like a computer. Atkinson and Shiffrin (1968) described the basis of cognitive information processing as a multi-store, multistage theory of memory.

Learning acquisition. Learning acquisition, according to Mayer (1982) is defined as a relatively permanent change in a person's knowledge or behavior due to experience. There are three basic components to the definition of learning. The first component is that the duration of this change in knowledge or behavior is long term. The second component states that the locus of the change is the content and structure of knowledge in the learner's memory or behavior. The third component states that the cause of change in the learner's knowledge or behavior is due to the experience in the environment and that it is not due to fatigue, motivation, drugs, physical condition or physiological intervention.

Motivation. Motivation is represented by two distinct types of motivation; intrinsic motivation and extrinsic motivation. Both types of motivation can exist in learners at the same time or on their own. A learner who performs a task for pleasure does so as a result of intrinsic motivation. Extrinsic motivation occurs when a learner performs tasks for rewards which are linked to successful performance (Keller, 2010). According to Keller (2010), "motivation refers broadly to what people desire, what they choose to do and what they commit to do" (p. 3). In other words, motivation explains why people do the things that they do.

Personalization. Personalization is the practice of presenting problems in a context that is designed to reflect the expressed real-world interests or preferences of students (Ku & Sullivan, 2002). Personalization is used as an instructional strategy to transform instructional context to reflect familiar referents of the learner with the intent of creating more meaningful instructional context (Akinsola & Awofala, 2009). There are three levels of personalization that can be applied to word problems; self-referencing, individual personalization and group personalization. Self-referencing personalization is the use of pronouns such as 'you' in the word problem (Moreno & Mayer, 2000). For example,

> You have $10 to buy bread. If each loaf of bread costs $2, how many loaves of bread can you buy?

Individual personalization incorporates individual personal interests and preferences into problem content (Akinsola & Awofala, 2009). For example,

> Mary (individual's name) has $10 to buy Dempster bread (individual's favorite brand of bread). If each loaf of Dempster bread costs $2, how many loaves of Dempster bread can Mary buy?

Group personalization integrates common group facts into problem content (Akinsola & Awofala, 2009). For example, Mr. Smith (most common/well-known teacher identified by group) has $10 to buy Wonder Bread (most common brand of bread identified by group). If each loaf of Wonder Bread costs $2, how many loaves of Wonder Bread can Mr. Smith buy?

Schema/schemata. Schema/schemata are cognitive constructs that permit the learner to treat multiple elements of information as a single element categorized according to the manner in which it will be used (Sweller, 1999).

Word problems. Word problems contain sentences that express a numerical relation between two variables (Hegarty, Mayer, & Monk, 1995).

Summary

This study was conducted to examine the effects of individual personalization of mathematical word problems on the learning acquisition and motivation of college learners. College learners' difficulty in demonstrating mathematical proficiency negatively affects college graduation rates which in turn negatively affect a nation's supply of a well-educated workforce required to drive future economic growth. The three questions which directed this study were (1) What is the effect of individual personalization on learner mathematical knowledge acquisition? (2) What is the effect of individual personalization on learner motivation to solve word problems? and, (3) What is the effect of individual personalization on long term learner motivation? Key terms and definitions relevant to this study were provided.

CHAPTER 2: LITERATURE REVIEW

Problem Solving

Problem solving is acknowledged as one of the key essential elements of mathematics. The process of problem solving as outlined by Williams (2003) required learners to understand the problem, devise a plan, carry out the plan, and then review the problem. In order to understand the problem, it was essential to determine not only what the problem is seeking but what information and conditions are provided. Finding a strategy to help solve mathematical problems includes analyzing the relationships between known and unknown quantities, reflecting on similar problems, or revising the original problem so that it can be related to a known problem (Williams, 2003). Story or word problems are an effective strategy for quantitative instruction that promotes meaningful learning. Mayer (1982) outlined three steps or processes that learner's experience which allows learning to become meaningful. The first step involves learners selecting information that is relevant, then organizing this information in a logical form, and lastly, associating the new information to an event or structure which learners already possess. Word problems provide opportunity to relate mathematics to the real word but without appropriate strategies, learners face challenges when applying mathematical rationale to various situations.

Definition of Problem Solving

Jonassen (2000) endorsed the definition of problem solving as a sequence of cognitive operations that are goal directed. These cognitive operations have two attributes. The first attribute involves the learner in a specific situation, constructing a mental representation or mental model of the problem which is also referred to as the problem space or problem schema. These internal mental models of problem spaces have many types of representations such as images, procedural knowledge, structural knowledge, and strategic knowledge (Jonassen, 2000). The mental construction of the problem space is the most important element for problem solving. The second attribute requires activity based manipulations of the problem space by either external physical or internal mental representations in order for conscious meaning making to take place (Jonassen, 2000). Comprehension, retention, and transferability of knowledge are enhanced when knowledge is constructed in a problem-solving context. Meaningful learning is enhanced when learners think more critically during problem solving (Jonassen, 2010).

Importance of Problem Solving

Jonassen (2010) emphasized the importance of problem solving as "the most important cognitive goal of education" (p. 2) and stressed the need for research in regards to designing problem-solving instruction. Problem solving is considered the most relevant learning activity for learner engagement since it is a skill that is used in everyday activities; both personal and professional. In order to problem solve, learners need to establish intent towards understanding the context of problems. Intentional learning requires the learner to identify goals for meaningful and attentive learning (Jonassen, 2010).

Problem solving is a meaningful and important type of learning and thinking. Problem solving involves many components such as domain knowledge that include concepts and rules, structural knowledge such as information networking and mental models, ampliative skills such as argument construction and application, and metacognitive skills such as assessing prior knowledge. Motivation and attitudinal components, such as persistence, exerting effort, and purposeful involvement are included as well as knowledge about self which includes conveying prior knowledge, sociocultural information, and personal strategies (Jonassen, 1997).

Solving Word Problems

Different types of processes are used to solve different types of problems. In order to solve for the unknown value in a story problem, known values embedded in the story problem narrative or context must be extracted and inserted into an algorithm. Difficulties arise when the story narrative or context is not relevant or interesting to the learner. Instead of transferring story problem skills to other problems, learners focus on surficial aspects or recall familiar solutions from previously solved problems (Jonassen, 2002).

In order to successfully solve story problems, learners require computational accuracy, semantic comprehension of relevant text, ability to visualize data and identify the deep structure of the problem. As well, learners must have the ability to sequence solution activities correctly as well as the inclination to assess the procedure to solve the problem (Jonassen, 2002). According to Riley and Greeno (1988), a successful problem schema is made up of three specific models; a semantic model of the situation described in text, a model of the deep structure of the problem, and a model of processing structure. Learners must then access the correct schema that will provide the solution procedure. Inserting the values into the correct formula to solve for the unknown value poses difficulties for the learners.

Most problem-solving models describe steps to solve well-structured problems. These steps include representing the problem, seeking the solution, and implementing the solution. Learners represent the problem by constructing a problem representation. The probability of solving the problem is influenced by the quality of the constructed representation. Learners identifying the represented problem type are more likely to use the solution related with the problem space (Shin, Jonassen, & McGee, 2003).

Learners who do not construct or trigger applicable problem representations must then continue to seek a solution to the problem. Novice solvers use domain-independent strategies that inhibit the development of problem schema. Expert problem solvers are considered efficient because they use domain-specific strategies explicit to problem types (Shin et al., 2003).

Word Problem Structure

Mathematical word problems are considered well-structured problems and their designs are based in information processing theory which advocates that learning outcomes can be used for any content domain (Jonassen, 1997). For example, well-structured problems are those that are typically found at the end of textbook chapters. Well-structured problems have several specific characteristics such as presenting all elements of the problem and are available to the learner as well-defined problems with known solutions. Well-structured problems include a limited number of organized, predictive, and prescriptive rule and principle applications and regular, well-structured rules and concepts in a well-structured and predictable domain. Correct and unifying answers and known and well-understood methods for solving in a way that is known or likely, is another characteristic of well-structured word problems. Lastly, well-structured problems have solution processes that are preferred and prescribed (Jonassen, 1997; Shin et al., 2003).

Problem Solving Skills

Common beliefs concerning skills gained in solving well-structured problems in the classroom, is that these skills are positively transferable to real world problems that are typically ill-structured but little evidence has been provided to support this assumption (Jonassen & Kwon, 2001). A study by Shin et al. (2003) compared the problem-solving skills for learners participating in an astronomy simulation indicated that problem-solving skills needed for solving well-structured problems and for ill-structured problems were different. Problem-solving skills needed to solve well-structured problems were strongly associated with domain knowledge and justification skills. Problem-solving skills needed to solve ill-structured problems were also strongly associated with domain knowledge and justification skills, as well as regulation of cognition and science attitudes (Shin et al., 2003).

Providing cognitive scaffolds such as argumentation can enable conceptual change in thinking which is required for problem solving resulting in meaningful learning. Argumentation is a way to resolve questions, disagreements, and issues. Using argumentative activities in learning environments enhances problem solving of both well-structured and ill-structured problems (Jonassen & Kim, 2010). A study by Nussbaum and Sinatra (2003) reported that learners that did not correctly solve well-structured physics problems increased their reasoning ability by constructing arguments for the correct answer. The effects of enhanced reasoning ability tested positive after one year (Nussbaum & Sinatra, 2003). According to Jonassen (2010), recalled knowledge that is not used in authentic tasks is ineffectual and readily forgotten.

Comprehending Word Problems

Both adults and children have strong aversions to word problems in spite of possessing required computational skills (Marshall, 1995). Difficulty solving word problems has been attributed to lack of personal meaning to the lives of students (Ensign, 1997), lack of motivation to solve word problems (Hart, 1996), and limited experience with word problems (Bailey, 2002). Learner difficulty with word problems has also been attributed to the inability to comprehend and translate the word problem into mathematical expressions (De Corte, Verschaffel, & De Win, 1985; Muth, 1984).

Comprehending mathematical problems correctly is the first and most important step in determining a solution (Cakir, Simsek, & Tezcan, 2009) and a lack of comprehension causes difficulties in solving mathematical word problems (Ku, Harter, Liu, Thompson, & Cheng, 2007). Translating word problems into mathematical form is required in order to solve word problems. Learners process the word problem by directly translating the word problem values into solvable algorithms (Jonassen, 2003). Learners, who experience difficulty with this task, have difficulty creating mental representations or schemas that connect the text of the word problem into a correct mathematical expression (Hart, 1996; Muth, 1984). Changing word problems to the correct numbers and symbols, especially with two step word problems causes confusion for learners (Harter & Ku, 2007). Connecting new ideas and skills to past experiences of learners enhances learner interest and effort towards solving problems (Mayer, 1998). The success of acquiring new information is influenced by the learner's ability to relate current information to new information (Miller & Kulhavy, 1991). Contexts that include abstract or unfamiliar situations increase the difficulty of solving word problems (Kintsch, 1986) while contexts that have been adapted to reflect real-life situations enhance mathematics learning (Cawelti, Grouws, & Cebulla, 1999).

Adaptive Context for Instruction

Adapting instruction to meet the needs of individual learners positively affects cognition and motivation. Learner attention and meaningful learning is supported by adapting context or theme that is relatable to learner interests and personal background (Morrison, Ross & Baldwin, 1992). Studies have shown that the amount of support necessary for learners can be determined by identifying the background of learners such as high or low achievers. Likewise, the type of context can also be determined by examining learner background and integrating this information into instruction which results in enhanced meaningfulness to the learner (Ross, 1983). A study by Ross (1983) examined the effect of adapting context of statistical word problems according to the area of study for undergraduate majors in nursing and education. The results indicated that nursing majors who completed instruction with medical examples performed better and had better attitude measures than those nursing majors who received nonmedical or abstract examples. Similar results were reported for the educational majors in terms of better performance and attitude with educational examples rather than non-educational or abstract examples. The themes in this study were controlled by the investigators and not by the learners; that is, learners did not identify which context was preferred as most interesting to them personally. Were these themes truly interesting or meaningful to the learners just because they were enrolled in a specific major?

Ross, McCormick, and Krisak (1986) further explored the effect of learner control on choice of thematic context of statistical word problems with undergraduate learners majoring in nursing and education. When given a choice, learners chose the context that reflected the area in which they majored over a non-major context or abstract context. There was no difference in achievement between learners who chose the context and learners who were given context that related to their major. The positive results reflected the well-defined interests and background of both nursing and education majors. However, not all groups or cohorts of learners have homogenous backgrounds. Learners can have a variety of interests and backgrounds such as those learners enrolled in undergraduate developmental math. It was hypothesized by the investigators that individualized context selection would be more favorable for learner achievement than group based context.

Personal Meaning and Word Problems

Studies have shown that enhancing personal meaning regarding mathematical word problems by incorporating personal interests and preferences, known as personalization, is an effective instructional strategy for mathematical acquisition. Personalization of instruction that incorporates relevant learner information into instructional word problems aids students in associating their personal information to unfamiliar course concepts (Anand & Ross, 1987; Davis-Dorsey, Ross, & Morrison, 1991; Ku & Sullivan, 2002; Lopez & Sullivan, 1992, 1991; Akinsola & Awofala, 2009). For example, if a student is interested in cooking or likes to shop at a specific grocery store, the mathematical word problem would be designed to reflect these interests by including aspects of cooking or the name of the grocery store.

Delivery Forms of Personalized Instruction

There are two forms of delivery for personalization; print and electronic forms. Studies who have used personalization of instruction in print form have indicated it to be effective for enhancing mathematical acquisition (Davis-Dorsey et al., 1991; Hart, 1996; Lopez & Sullivan, 1991, 1992,). Likewise, personalization instruction delivered through electronic means has also shown to improve mathematical acquisition (Anand & Ross, 1987; Ross, Anand, & Morrison, 1988; Ku et al., 2007). The choice of delivery in past studies has been influenced by availability of computers and amount of instructor preparation time since group personalization takes less time to prepare than individual personalization of educational materials.

Effects of Personalization

According to Bates and Wiest (2004), personalizing mathematical word problems has positive effects for learner understanding, achievement, and interest. Personalization supports the linking of mental representations to the word problem text needed for solving word problems (Hart, 1996). Personalization improved memory and recall in a study by Miller and Kulhavy (1991). College undergraduate learners provided personally meaningful modifiers to objects contained within text sentences. When asked to recall the sentences, learners who had used personally meaningful modifiers had a significantly greater recall that those learners who did not create personally meaningful modifiers. A greater effect of recalling information was attributed to learners having incorporated personalized representations during the encoding process (Miller & Kulhavy, 1991).

Personalization and Motivation

Personalized math word problems are intrinsically more motivational for students because they can draw and maintain attention to the problem text while creating strong and memorable encoding that increases the retrieval abilities of associated material (Mayer, 1998). By increasing the meaningfulness of word problems, personalization facilitates the learners to place themselves mentally in the word problem. Personalization reduces the cognitive demand of problem solving as it constructs stronger associations to the word problem solving task (Lopez & Sullivan, 1992).

Personalization and Learner Levels

Extensive literature reviews of empirical studies indicate that the majority of studies using group or individual personalization are at elementary grade levels. Few studies have been reported at the high school level and no studies have been found at the college level.

Positive effects of personalization on mathematical achievement, interests, and motivation have been reported in studies with learners enrolled in upper elementary, middle, and senior secondary grades of mathematics (Akinsola & Awofala, 2009; Anand & Ross, 1987; Davis-Dorsey et al., 1991; Hart, 1996; Ku & Sullivan, 2002; Lopez & Sullivan, 1991, 1992). Advancing grade levels reflect increasingly difficult mathematical problems. The use of personalization to solve mathematical word problems according to Bates and Wiest (2004) positively influenced learner achievement. For example, Akinsola and Awofala (2009) reported that personalization of mathematical word problems for senior secondary learners, resulted in a greater level of developed schemata for processing information in the real world (Akinsola & Awofala, 2009).

Parker and Lepper (1992) pointed out that the need for methods to enhance learner interest techniques increases with the age of the learner. In contrast, there is a lack of consistent evidence to show that personalization has a positive effect on academic achievement by learners at the fourth grade and below. According to Simsek and Cakir (2009), learners in lower elementary grades do not possess developed schemata that would allow them to process real-world information. Personalization may be important or more effective on more demanding or unfamiliar, mathematically complex, cognitive tasks.

Personalization Levels

There are three levels or approaches to personalization that incorporate learner referents in instructional context. The first approach uses self-referencing words like "you" in the instructional context. The other two approaches, individual and group personalization, both require surveying the learners for their personal interests and preferences and then incorporating this information into the context of instruction. These two approaches differ in that group personalization uses the most common personal interests and preferences in the instructional context while individual personalization reflects individual learner preferences (Akinsola &Awofala, 2009). Incorporating common interests of the individual or of the group is effective according to Lopez and Sullivan (1992).

Individual Personalization and Mathematical Achievement

Significant positive mathematical achievement has been reported for studies examining the effect of individual personalization of mathematical word problem instruction. Anand and Ross (1987) explored the effect of individually personalized word problems on fifth and sixth grade learners. Individual learner interest and background were identified using learner questionnaires. This information was imbedded into mathematical word problem examples for the treatment group while other learners received concrete examples using realistic situations or abstract examples. Learners who received individual personalization instruction demonstrated significantly greater achievement gains and more positive attitudes toward learning than the other two conditions. Benefits gained by the individual personalized treatment group were due to learners' increased attentiveness to personalized problems as well as forming external connections between the problem information and existing schemata (Anand & Ross, 1987).

Ross, Anand, Morrison and O'Dell (1988) compared the effect of mathematics achievement with abstract context, concrete context, and individually personalized context using both forms of delivery, print and electronic. There was no difference in achievement for either delivery forms for learners receiving personalized, abstract, or concrete word problems. However, there were significant differences in achievement in regards to the type of context. Learners in the individual personalization treatment group were significantly superior in mathematical achievement than the learners in the abstract group but not significantly superior in the concrete context groups. However upon further analysis of learner ability and context, it was determined that low-middle ability learners performed significantly greater than learners in the abstract or concrete context. The high-ability learners performed better with both personalized and concrete compared to abstract context.

Davis-Dorsey et al. (1991) examined the effect of individual personalization of mathematics instruction with and without rewording mathematical word problems on fifth and second grade learners. The results indicated that the fifth graders had greater achievement with personalization alone and not with personalization and rewording while in comparison, the second graders realized greater mathematics achievement using both personalization and rewording only. Fifth graders, considered more experienced problem solvers used their schemata for representing the problem structures and did not require rewording to experience benefits of individual personalization.

Personalization contributes to retrieval of related information by providing meaningful associations for the learner. A previous study by Lopez and Sullivan (1991) reported that individual personalization effect was significantly higher than non-personalized treatment on both one-step and two- step mathematical word problems with eighth-grade learners. Higher achievement was attributed to the effect of individual personalization due to the increase in comprehension of word problems. Since personalization increases retrieval of associated material (Miller & Kulhavy, 1991), learners were better able to connect with the problem-solving task and place themselves mentally in the word problem.

Complex Word Problems and Personalization

There is a stronger effect of personalization with more complex mathematical word problems such as two-step math word problems. A study by Lopez and Sullivan (1992) compared the effectiveness of group personalization to individual personalization and non-personalization instruction on the mathematical achievement by seventh grade learners solving one-step and two- step math word problems. Achievement levels between the three groups regarding solving one-step word problems did not produce significant results. One-step mathematics problem required a single mathematical operation while a two-step mathematics problem required two or more operations to correctly solve the mathematical word problem. However, both individual and group personalization produced significantly greater math achievement compared to non-personalization for solving two-step math problems only. Individual and group personalization groups were not significantly different from each other for solving two-step problems. Since two-step problems have a greater number of mathematical operations and are lengthier than one-step problems, a heavier cognitive demand was placed on learners (Lopez & Sullivan, 1992). Providing familiar information in personalization instruction enables the learner to understand and process the word problems thus reducing the learner cognitive demand.

Personalization has a stronger effect on lower-level math knowledge learners than on higher-level math knowledge learners. Ku, Harter, Liu, Thompson, and Cheng (2007) investigated the effects of individual personalization of mathematical word problems with learners in the sixth to eighth grade level. Higher-level math knowledge learners and lower-level math knowledge learners were equally represented in both the individual personalization instruction treatment and the non-personalization treatment group. Post-test results indicated that individual personalization did not have a significant effect on learner achievement; that is, reported achievement by learners in the individually personalization treatment group did not differ from the non-personalization group. However, upon further analysis, achievement by lower-level math learners in the individual personalization treatment group achieved significantly greater scores than lower-level math learners in the non-personalization group. Ku et al. (2007) hypothesized that lower-level math entering knowledge learners in the personalized treatment put forth greater effort in thinking about the word problems than did the non-treatment learners. Post-test scores of higher-level math learners in the individual personalization treatment group and non-treatment counterpart were virtually identical and showed no significant effect.

Individual Personalization and Motivation

Several studies have reported positive attitudes of learners in individual personalized treatment groups. Anand and Ross (1987) noted that attitudes of learners in personalized treatment groups were significantly greater than learners in abstract or concrete contexts. Although the personalized context problems were significantly greater in text length compared to abstract and concrete, there was no significant study time difference between the groups. This indicates that any motivational effects for the personalized treatment group were not due to extra time spent with the personalized materials; rather the focus or interest was on the personalized text itself (Anand & Ross, 1987).

Lopez and Sullivan (1992) also examined attitude effects and determined that learners in the individual group had a significantly greater attitude than group or non-personalization treatments. Learners in the individual personalization treatment specified that the instruction contained more familiar information such as persons, things, and places and based on this experience the learners in the individualized treatment group expressed their interest to solve more individual personalization mathematical word problems in the future.

Ku et al. (2007) reported positive attitude by learners in the individual personalization instruction group. Given several statements regarding attitude towards solving math word problems, learners in the individual personalization instruction expressed positive attitudes. Learners in the individual personalization expressed that the instruction was easy and likeable. As for future efforts, those in the treatment group expressed that they would do more math problems that reflected personalization. The authors concluded that personalization would increase the learners' return to task motivation (Ku et al., 2007).

Group Personalization and Achievement

Studies involving group personalization instruction indicate positive effects on solving mathematical word problems. Enhancing comprehension of word problems by using familiar contexts in group personalization instruction in a study by Hart (1996) resulted in positive mathematics acquisition by learners in the sixth grade. Results from an eight week study by Hart (1996) indicated that alternating weeks of personalized group instruction using mathematical word problems resulted in greater academic achievement by learners in the sixth grade. The total assessment points based on instruction using group personalization were greater than those assessments based on standard textbook instruction which did not reflect group personalization. The group personalization instruction wording was more complex and in spite of the greater amount of thinking required to solve these problems, learners demonstrated higher achievement, greater motivation and greater positive attitude towards problem solving. By providing a context that was familiar to learners, comprehension of the word problem was enhanced which facilitated the process of successfully translating the words to writing the mathematical expression (Hart, 1996).

Mathematics achievement can be increased by using group personalization test questions alone; that is, instruction that reflects group personalization is not necessary to see a positive effect on mathematics achievement. Ku and Sullivan (2000) examined the effect of group personalization of instruction on mathematics achievement of fifth grade Taiwanese learners. Learners were blocked into high-level and low-level math ability and after pre-testing were randomly assigned to the personalization treatment group and the non-treatment group. Post-test questions were in both personalized and non-personalized forms. Post-test results indicated that the personalized instruction treatment did not have a significant effect on mathematics achievement. This result is not consistent with other studies that reported a significant effect using group personalization (Anand & Ross, 1987; Lopez & Sullivan, 1991, 1992). The non-significant effect of group personalization was attributed to the strong performance of higher-math ability learners in both the treatment and non-treatment groups. Ku and Sullivan (2000) hypothesized that the type of group personalization used was not powerful enough to obtain a significant effect for personalization. As well, the investigators emphasized that Taiwanese learners have had strong cultural influences of math and science in comparison to U.S. culture. In regards to post-test problem type, learners in both treatments performed significantly better on personalized post-test problems than non-personalized problems. Learner success with post-test questions that reflected group personalization was attributed to the familiarity offered by the word problems. Familiarity of the word problem context reduced the learners' cognitive load in understanding and processing the elements of the problem and facilitated the ease in which the learners solved the group personalization word problems. Familiarity with instructional word problem context positively influences mathematics achievement. In this case, familiarity with test word problems alone, without instructional personalization, was considered a factor to explain the significant effect of group personalization.

Akinsola and Awofala (2009) examined the effect of group personalization on mathematical acquisition and self-efficacy on senior high school learners. Learners in the group personalization instruction treatment demonstrated significant positive achievement towards solving word problem compared to learners that did not receive group personalization instruction. Learners in the treatment group of group personalization experienced a reduced cognitive load in comprehending and processing elements of word problems compared to learners who did not receive treatment. Personalization was found to be more effective with demanding or unfamiliar, mathematically complex, cognitive tasks.

Group Personalization and Motivation

Several studies have reported group personalization to have positively affected learner interest and motivation. A study by Herndon (1987) indicated that group personalization of instruction that does not result in significant achievement may still result in a significant effect of motivation. In this study, personalization of conditional syllogisms according to group interests significantly affected the motivation level by senior high school learners to return to task.

Hart (1996) reported that the majority of learners preferred personalization word problems describing the word problems as familiar and interesting. These learners were more enthusiastic, interested, and motivated to solve mathematical word problems.

Ku and Sullivan (2000) measured and compared attitude of learners in group personalization instruction and those learners in non-personalized instruction. Learners in the group personalization treatment group preferred group personalized instruction rather than non-personalized instruction (Ku & Sullivan, 2000). These learners indicated a greater level of enjoyment of instruction as a result of imbedded familiar content. The learners also described the group personalization instruction as more interesting and indicated that in the future, they would prefer word problems that were personalized. Ku and Sullivan (2000) hypothesized that learners would have greater willingness or motivation to solve personalized word problems in the future.

Self-efficacy of senior high school learners was significantly greater than learners that did not receive personalization treatment. Increased levels of confidence and enjoyment positively influenced self-efficacy as a result of achievement (Akinsola & Awofala, 2009).

Cognitive Information Processing

Atkinson and Shiffrin (1968) described the basis of cognitive information processing as a multistore, multistage theory of memory. A major assumption of the theory is that the learner has three memory systems that are used in cognitive information processing which are sensory memory, short-term or working memory, and long-term memory. These memory systems receive information from the environment and transform the information for storage and use in both performance and memory. Sensory memory involves the learner recognizing patterns in the environment and then reorganizing and coding the information. Short term or working memory allows the learner to retain the information for only a short period of time in order to understand the information and to associate it with information already stored in long term memory. Short term or working memory cannot process large amounts of information at once and can become overloaded. Working memory has a limited capacity of seven elements for storing information and two to four elements for processing information (Miller, 1956). Long-term memory does not have such small limitations and can store information for long periods of time in order to allow access to the information by the learner at a later time. Driscoll (2005) further explained that processes of attention, encoding and retrieval hypothetically have an effect on the information as it is received, transformed, and stored. The process of attention influences learning by directing the learner's attention to specific material to be learned. Encoding information is a process that allows the learner to make personally meaningful associations between existing knowledge and new knowledge while the retrieval process allows learners to apply recalled information from memory storage to specific contexts. Feedback from an information processing viewpoint can provide the learner with an appraisal of the performance or knowledge exhibited as well as corrective information that can be used for future performance. A learner's prior knowledge can enhance information processing by recalling cues that associate new knowledge with prior learning. Cognitive information processing can be enhanced by incorporating instructional designs that can strengthen the processes of attention, encoding and retrieval (Driscoll, 2005).

Motivation

Mathematics instruction at all levels poses instructional challenges (Deitte & Howe, 2003). Many learners deny the importance of mathematics due to trendy social pressures and the amount of effort required (Sullivan, Tobias, & McDonough, 2006). The lack of engagement by learners in mathematics studies leads to lower achievement. Perhaps, as Proctor, Floyd, and Shaver (2005) pointed out, non-cognitive influences such as motivation, anxiety, and poor instruction are to blame. Indeed, Koller, Baumert, and Schnabel (2001) clearly state that mathematics is a difficult subject and motivational factors are important for enhancing learning. According to Wolters and Rosenthal (2000), motivated learners exert more effort and persistence in learning than those learners who have less motivation. With a flexible academic structure offered by colleges, learners face motivational challenges of pursuing learning goals (Glynn, Aultman, & Owens, 2005).

Motivation Categories

There are four basic categories or orientations regarding motivation when examining student learning at the college level. These four orientations are behavioral, humanistic, cognitive, and social (Glynn, et al., 2005).

The behavioral orientation examines the effects of incentives and reinforcement on behavior. For example, offering scholarships for learners with high grade point averages would be an external incentive and receiving the scholarship would then be the reinforcement. The resulting motivation takes place when the learner perception of reward is seen as positive feedback. However, if the reward is perceived as controlling, then it serves to undermine future learner effort (Weiner, 1990). Other problems, such as learners not developing intrinsic motivation to learn, results from efforts to shape learner behavior with the use of external incentives and reinforcements. Learner attention is concentrated on the external incentive itself rather than as a feedback regarding academic progress (Glynn et al., 2005). Deci, Koestner and Ryan (1999) reported a decrease in learner motivation when the learner naturally found the task motivating.

The humanistic orientation of motivation is based on Maslow's self-actualization theory (Maslow, 1968) in which humans are compelled to achieve maximum potential unless obstacles such as hunger, thirst, and safety are involved. College learners' freedom to make choices, capacity for personal growth, and the need to accomplish are the focus of humanistic educational research (Reeve, 1996). The learners' ability to make choices and control actions is known as self-determination (Deci, Vallerand, Pelletier, & Ryan, 1991).

The third motivation orientation is based on cognitive theories that focus on the college learners' goals, plans, expectations, and attributions (Schunk, 2004). An attribution takes place when learners try to understand or explain the causes of their successful or failing performance (Weiner, 1990). Statements by learners that express cause about learning and performance influence the continuing motivation to learn (Weiner, 1979).

The social orientation to motivation stresses the learners' identities and their interpersonal relationships in learning communities such as Websites, activity centers, and interrelated courses (Glynn et al., 2005). Knowledge is shared amongst members within learning communities and as a result learners gain knowledge and learners' identities are developed. Learners are motivated to learn the behavior, value, attitudes, in order to maintain membership (Lave & Wenger, 1991). Members of learning communities use the process of modeling in order to learn (Greeno, Collins, & Resnik, 1996).

Motivation Constructs

Motivation constructs can be viewed as belonging to three categories: traits and states, learners' beliefs, and learners' responses to others' expectations (Glynn et al., 2005). Activity level, interest and curiosity are constructs that represent learners' traits and states. These constructs are useful when characterizing intrinsic and extrinsic motivation to learn. Self-determination, goal orientation, self-regulation, and self-efficacy are constructs that indicate learners' beliefs. The third category construct focuses on the effect of learner motivation based on expectations of learners from others such as instructors, peers, and family.

Activity level and anxiety construct. A learner's readiness for action in terms of physical and mental state is referred to as activity level. Activity levels that are too low can lead to learner boredom and even anxiety. High levels of anxiety can disrupt both learning and performance which then results in lower motivation levels (Glynn, et al., 2005).

Learner anxiety can occur as a temporary association with a situation. If a learner is underprepared, then an activity like a pop quiz would lead to a state of anxiety (Glynn et al., 2005). According to Cassady and Johnson (2002), moderate anxiety increased motivation levels. However, learners who experienced anxiety in any context regardless of preparation readiness, were said to have anxiety in a trait form. That is, trait anxiety is a constant personality characteristic of a learner (Glynn et al., 2005).

Anxiety and mathematics. High achieving mathematics learners possessed more positive attitudes and demonstrated greater academic achievement (Chapell, Blanding, Silverstein, Takahashi, Newman, Gubi, & McCann, 2005). As well, high achieving mathematics learners have less anxiety during problem solving (Pajares, 1996). The influence of high levels of anxiety on learners with low calculation skills exhibited poor motivation during mathematics instruction (Proctor, et al., 2005). Anxiety negatively affected the learning process and performance by reducing a learner's perception of self-efficacy for solving mathematics problems (Malpass, O'Neal, & Hocevar, 1999, Pajares & Miller, 1995). Bandalos, Yates, and Thorndike-Christ (1995) reported that learners with elevated anxiety levels developed negative perceptions regarding ability, tended to focus on these negative perceptions, and had lower persistence.

Interest and curiosity. Learners exhibiting interest or curiosity indicate a disposition towards inquiry and discovery of instruction (Glynn et al., 2005). According to Wade, (2001), learner interest is associated with increased knowledge, positive emotions, high value, and personal significance. There are two types of interests; individual or personal, regarded as long-lasting or persistent, and situational, which is considered temporary. Alexander and Murphy (1998) stated that learners with high interest experienced higher levels of achievement and low levels of achievement are associated with learners with lower interest levels. Gaining learner interest and encouraging curiosity results in acquiring learner attention (Keller, 2010). Using various instructional approaches in learning environments such as a training session or classroom can maintain attention by learners (Keller, 1987a).

Interest and mathematics. Activities that reflect interesting and useful aspects of mathematics motivate learners (Deitte & Howe, 2003). Learners motivated by interest in mathematics have greater achievement and pursue higher levels of mathematics studies (Koller, Baumert, & Schnabel, 2001). According to Koller, Baumert, and Schnabel (2001), academic interests in specific subjects are intrinsically motivating for academic achievement.

Intrinsic and extrinsic motivation. Intrinsic motivation occurs when learners are engaged in a learning activity that is satisfying in itself while extrinsic motivation is stimulated through incentives or rewards (Lin, McKeachie, & Yung, 2003). Activity level, interest and curiosity are derivatives from intrinsic motivation. Extrinsic motivation occurs when learners are engaged in a learning activity in order to achieve an external reward. Extrinsic rewards can result in short-term positive effects and possible long-term negative effects (Elliot & Knight, 2005). Learners can be motivated by both intrinsic and extrinsic motivations at the same time as these two motivations are not considered incompatible (Pintrich, 2000). Intrinsic and extrinsic motivations share a complex relationship with other factors that affect learner achievement. However, higher levels of intrinsic motivation are positively associated to achievement while higher levels of extrinsic motivation are negatively associated to achievement (Lin et al., 2003).

Intrinsic and extrinsic motivation and mathematics. According to Glynn et al. (2005) intrinsic motivation is derived from motivational constructs such as activity level, interest and curiosity. Middleton and Spanias (1999) stated there are two types of academic motivation concerning academic settings which are intrinsic and extrinsic. Learners who are intrinsically motivated enjoy learning for the sake of learning. Intrinsically motivated learners focus on learning goals such as understanding and mastery of mathematical concepts and demonstrate many desirable learning behaviors.

Intrinsically motivated behaviors include an increase in greater complex processing and monitoring of comprehension, creativity, risk taking, time on task, persistence in failure situations, choice of challenging tasks in the absence of an external or extrinsic reward, and choosing deeper, more efficient learning strategies and performance (Lepper, 1988).

According to Gottfried (1985), intrinsic motivation was related to learner perceptions concerning mathematics and indicated if the learner is motivated by grades or curiosity. Intrinsic motivation also indicated if the source for academic achievement is mastery orientation (Gottfried, 1985).

Intrinsic motivation is more complex than the additive effects of perceived competence, ability, and achievement. Learners who value mathematics are those who believe that they are capable of doing well in mathematics. Likewise, learners who do not believe that they are capable of performing well in mathematics do not value mathematics. Before intrinsic motivation is developed, learners must be comfortable with mathematics, must expect to succeed, and must be challenged to achieve (Middleton & Spanias, 1999).

Self-determination. Self-determination refers to the learner's ability to make choices and have control over their learning (Deci et al., 1991). Self-determination focuses on the quality of the motivation and the reasons why learners engage in a specific task rather than the quantity of motivation. Examples of self-determination activities include providing learners leadership opportunities, creating positive learning environments, cultivating relationships with peers and family, and providing suitable challenges and feedback. College learners according to Deci (1996) have a need to feel independent and competent and derive these feelings through intrinsically motivated activities. Self-determined motivation results in positive results in achievement and emotional well-being (Deci, 1996). Other positive results for college learners include greater perception of competency, creativity, interest, learning, and a greater inclination to choose challenges (Glynn et al., 2005). In contrast, extrinsically motivated activities weaken feelings of independence and competency and it becomes challenging for these learners to become intrinsically motivated. As a result, learners develop learned helplessness which is a belief that personal successes are uncontrollable (Schubert, Walker, & Stewart, 2000).

Self-determination and mathematics. Johnson (2006) reported that learners supported both extrinsic and intrinsic reasons for engaging in mathematics. High achievers at the extrinsic level were not as motivated by external consequences as low achievers. Learners with high perceptions of competence were more motivated by extrinsic consequences than learners with low perception of competence.

Goal orientation. Actively setting goals is an important source of motivation according to Bandura (1977). Motivation that affects learners pursuing specific goals is termed goal orientation. Goal setting positively influences learners in terms of attention, effort, persistence and developing new strategies (Glynn et al., 2005). The expectancy-value theory of achievement motivation postulates that behavior is determined by the intensity that learners value a specific goal and whether the learner expects to succeed in realizing the goals based on specific learner actions (Wigfield & Eccles, 2000). College learner motivation and perseverance increase when goals are challenging, concrete, and are close in time (Pintrich & Schunk, 1996).

There are two types of goal orientation which are learning goal orientation and performance goal orientation and learners can have varying degrees of both types (Glynn et al., 2005).

College learners that take responsibility for their learning and attribute success to their own effort are said to have a learning goal orientation. These learners seek to master their performance and related strategies to their performance and are not hesitant to request feedback. Since failure does not intimidate these learners' sense of self-efficacy, challenging goals are set appropriately and the response to failure is appropriate (Glynn et al., 2005).

College learners that are concerned with how they are viewed by peers and instructors and concerned with achieving good grades are said to have a performance goal orientation. These learners have self-esteem founded on external evaluations of their performance and put forth greater effort only on graded activities. Procrastination or apathy occurs when positive external evaluations are not received (Glynn et al., 2005).

Goal orientation and mathematics. Learners in a remedial college mathematics course who focused on learning goals rather than performance goals had greater mathematical achievement that those learners who focused primarily on performance goals. In addition to greater achievement, learning goal learners were also less anxious than performance goal learners (Ironsmith, Marva, Harju, & Eppler, 2003).

Self-regulation. An essential element of self-regulation is goal setting (Schunk & Zimmerman, 1997). College learners who were motivated by self-regulation established their goals for learning and implemented strategies to monitor progress towards their goals (Tuckman, 2003). College learners who perceived control of their learning exerted a greater effort, chose more demanding tasks, and stayed on task longer (Schunk, 1996). As a result, these motivated learners were adaptive and implemented strategies to increase success in future prospects. During situations of failure, the learner with perceived control attribute the failure to controllable internal causes such as lack of preparation. Learners who perceive that they are not in control focus on personal limitations become uninterested in learning (Glynn et al., 2005).

Learner self-regulation is not a permanent characteristic. Learners can use past experiences and change goals and strategies to enhance learning. In contrast, unsuccessful learners show little awareness of the usefulness of past learning experiences (Zimmerman, 1998).

Self-regulation and mathematics. Learners who perceive instructional materials to be more interesting, useful, and important tend to use deeper processing strategies such as metacognitive control (Pape, Bell, & Yetkin, 2003). According to Montague, Warger, and Morgan (2000), learners engaged in solving word problems should use a metacognitive control strategy of restating or rephrasing mathematical word problems. By implementing this strategy, learners translate the linguistic information into a numerical model or representation but do not alter the meaning of the word problem.

Another metacognitive strategy that is useful for problem solving in mathematics includes imagery to process the problem which facilitates the establishment of an internal representation of the numerical model (Montague et al., 2000).

Self-efficacy. Learners' beliefs about themselves in regards to task difficulty and task outcome, strongly influence learner motivation. Self-efficacy, according to Bandura (1997), is defined as "beliefs in one's capabilities to organize and execute the courses of action required to produce given attainments"(p. 3). In other words, self-efficacy is about the beliefs that the learner has about personal capabilities to organize and implement the actions needed to achieve their goals. Since self-efficacy is domain specific, learners may have both high and low self-efficacy depending on the domain. For example, a learner may have low-efficacy in mathematics but high-efficacy in history (Bong, 2004). Sources for a college learner's self-efficacy come from mastery experiences, vicarious experiences, and social persuasions (Bandura, 1997). The greatest influence on a learners' sense of efficacy in a specific area are the learners' actual experiences, referred to as mastery experiences. Learner experiences deemed successful enhance efficacy while experiences of failure decrease the sense of self-efficacy. Vicarious experiences occur when learners observe others as models, such as instructors or peers. A learner's strong association with the model results in a greater influence on the learner. Social persuasion from sources that learners respect can influence learners to put forth a greater effort even when the learner experiences a temporary stumbling block (Glynn et al., 2005). Lower learner self-efficacy can negatively affect learner achievement if the model is perceived by the learner as not having confidence in the learner (Tsui, 2001).

Motivation in terms of persistence, goal setting, effort, and selecting appropriate strategies, increases when college learners have high self-efficacy (VanZile-Tamsen & Livingstone, 1999). According to Zimmerman (2000), low self-efficacy college learners abandon a task if perceived as too difficult. By using specific learning strategies and adopting short-term goals to monitor progress, college learners can enhance both self-efficacy and performance (Graham & Weiner, 1996).

Self-efficacy and mathematics. Several studies report that mathematics achievement is affected by self-efficacy. Pajares (1996) reported that mathematics problem solving was influenced by high self-efficacy in a study controlling cognitive ability and mathematics anxiety. Mathematical self-efficacy was determined as the best predictor variable of college learner performance (Bourquin, 1999). Greater computational accuracy was reported for learners with high-efficacy when compared with learners with low-efficacy (Pajares & Graham, 1999). Pajares and Graham (1999) also reported a statistically positive significant relationship between persistence or engagement and self-efficacy.

Expectations. According to Glynn et al. (2005), expectations of learners and those strategies based on those expectations, known as the Pygmalion effect, affected the level of motivation of learners enrolled in general education college courses. According to Smith, Jussim and Eccles (1999), expectations of learner performance by instructors can influence the motivation level of learners. When instructors have high expectation of learners via means of critical feedback on performance, learners sustain their intrinsic motivation (Butler & Nissan, 1986). Low expectation of college learners by instructors result in inconsistent feedback such as ignoring performances or praising inadequate performances (Simons, Covington, & Van Rheenen, 1999).

Expectation and mathematics. Meece, Parsons, Kaczal, Goff, and Futterman (1982) examined sex differences in mathematics achievement. The researchers stated that instructors and parents need to be aware of their attitudes perpetuating stereotypical views that mathematics achievement and math-based careers for females is inappropriate. However, Brophy (1986) cautioned that many sex differences in mathematics achievement are due to differences in beliefs concerning importance and relevance of mathematics rather than discriminatory practices by instructors.

Motivation and Keller ARCS Model

Motivation is an important factor for learning and achievement (Walberg, 1984). According to Keller, the many motivational theories and orientations, although useful to organize present research, limits both clinical applications and new research ideas. The basis of theories are defined and supported by specific premises that function within specific domains. Keller pointed out that practitioners need to have a holistic understanding of specialty areas in order to problem solve (Keller, 2010).

Motivation is defined by Keller (2010) as "that which explains the direction and magnitude of behavior" (p. 3). Motivation studies examine both the goals that are chosen by the learner to pursue and the intensity of that pursuit in order to achieve the goal.

Keller (1987a) stated that learner motivation can be improved both rationally and predictably by meeting two requirements. The first requirement is to understand the motivation by comprehending the foundational components of the motivation to learn and by having an overview of instructional strategies that will provide a positive effect on the foundational components. The second requirement is to determine what type and number of strategies to use as well as to determine a method of designing these strategies into a course. Keller (2010) pointed out that a problem-solving approach to instructional design was more feasible and practical than a prescriptive approach due to the high variability of individual learner expectancies, attitudes and values. In other words, what may be motivating for one learner, may not be motivating for other learners. Keller's ARCS (Attention Relevance Confidence Satisfaction) Model which is grounded in expectancy-value theory provides a guide to understanding motivation in terms of four major categories and 12 subcategories of learner behavior and how to incorporate reflections of these categories when analyzing the audience and when designing for instruction. In other words, each step of instructional design, analysis, design, development, integration, and evaluation can be assessed according to Keller's four categories of motivation. For example, one of the instructional design steps, evaluation of instruction, can be assessed by reviewing each category and subcategory of the ARCS model (Keller, 1987a).

Elements of motivation include both the direction and magnitude of people's behavior according to Keller (2010). Direction indicates the pursuit of specified goals while magnitude describes how intensively and how vigorously those goals will be pursued. The foundation and frame of reference for the components of the ARCS model are based on this type of theory.

Macro model of motivation and performance. The Macro Model of Motivation and Performance is based on systems theory that shows the relationships between input, process, and output. Effort, performance, and consequences, the measurable outputs of motivation and performance, are located in the middle of the model. Psychological or personal characteristics affecting motivation, learning, performance, and attitudes are located in the top row and represent the inputs of this system.

Environmental elements that influence these behaviors are located in the bottom row. Attention, relevance, confidence are the main components of the ARCS model and are situated in the far left upper corner. The psychological foundation for attention is curiosity, for relevance is motives and for confidence is expectancy. Attention and relevance are in one box and confidence is in another box. The value box is divided into attention-curiosity and relevance-motives in keeping with the primary conceptual foundation of each. The category of satisfaction is situated in the upper right of the diagram because it is considered a product of integrating the actual performance consequences in regards to the occurring intrinsic and extrinsic outcomes and the learner's cognitive evaluation of these outcomes. The learner's cognitive evaluation means that the learner experiences positive or negative feelings and attitudes when they compare the actual consequence of their performance to what they expected and to what other people have received (Keller, 2010).

The model shows the combination of motivation in terms of the amount of effort exerted towards achieving a goal and the knowledge and skills that influence overall performance. The model addresses the environmental function in terms of motivation, learning and performance (Keller, 2010).

The feedback loops from the output line back to the expectance-confidence box demonstrates that the level of learner success and the success that leads to the expected outcome has an effect on a learner's expectancies for future success. Another feedback loop from satisfaction to attention and relevance shows that the learner's actual experiences with the outcomes of a goal-oriented set of behaviors influence the value attached to that goal in the future (Keller, 2010).

ARCS-V Model

The traditional expectancy-value theory states that one's behavior potential is a result of the strength of personal expectations for success and personal value of the desired goal. In other words, the behavior required to achieve a goal will occur if one has a strong expectation for personal success and values the desired goal. The Macro Model of Motivation and Performance assumes that behavior potential and action are automatic. This means that one will work towards achieving the goals with the highest result of expectancy and value. This assumption cannot be held true in every instance since there are many goals and goal strengths change according to the significance of other goals which may lead to goal conflict. The behavioral potential is then dependent on both the strength of original of intent and self-regulatory behaviors in response to goal conflict. These self-regulatory behaviors are referred to by Keller (2010) as volitional skills. Volition is defined as the measures or actions taken in order to achieve a goal. There are two phases of volition: commitment or pre-action planning and self-regulation or action control (Keller, 2010).

Pre-action planning or commitment is made up of three elements. The first element is the individual's initial attraction to the goal, followed by the development of intentions to the goal, and finally planning for action using these intentions (Gollwitzer, 1993 as cited in Keller, 2010, p.8). Keller (2010) stated that maintaining commitment and goal orientation is required for the management of intentions. The strength of the intention depends on the commitment to the goal and the creation of a solid plan that specifies the method and timing to achieve the goal (Gollwitzer, 1993 as cited in Keller, 2010, p.8).

The second phase of volition is referred to as action control or self-regulation. Kuhl (1984) refers to this facet as action control theory in which there are six strategies that help achieve the commitment to realizing the goal. These strategies strengthen one's resolve to the task and evading distractions. The first action control strategy is called selective attention and serves the purpose to protect the current intention by limiting the processing information of rival action susceptibility. Encoding control selectively encodes the aspects of incoming stimuli of the current intention and refutes extraneous aspects which results in assisting the protective role of volition. Emotional control deals with the management of emotional states. Emotional states that support the current intention are allowed while those that weaken it are subdued. The fourth strategy is motivation control which preserves and restores the importance of the current intention. This is particular useful when the original tendency is weak. Establishing a distraction free environment is the role for environmental control. It includes the creation of social commitments with the intent of protecting the current intention. The last strategy, parsimonious information processing, is needed in order for decisions to be made to keep those active behaviors necessary to support the current intentions. It also includes the knowledge concerning the appropriate amount of information necessary and when to halt the processing.

The expansion of the macro model reflects pre-action planning which addresses intentions and commitment and action control concerning self-regulation resulted in the Motivation, Volition, and Performance theory. The expanded model includes two more behavioral outcomes which are effort direction and effort initiation. Effort direction in the expanded model is a modified version of effort from the macro model. Effort direction deals specifically with the selection of an identified goal. Effort initiation refers to intentions and commitment. The third behavioral outcome is referred to as effort persistence which is the outcome of action control.

Motivation and ARCS

Means, Jonassen, and Dwyer (1997) completed a study that examined the effects of instruction that reflected intrinsic relevance with instruction that reflected embedded extrinsic relevance-enhancing strategies. The strategies were based on Keller's ARCS

Motivation Model that stated that strategies embedded in instructional materials can enhance learner cognitive performance. Specifically, the assumptions of the ARCS model suggested that these strategies affected the learner by enhancing attention to instructional materials as well as enhancing perceptions of relevance, confidence, and satisfaction of learning from these instructional materials. The ARCS model also stated that instructional materials must include embedded relevance-enhancing strategies if there was a lack of intrinsic relevance. Relevance-enhancing strategies were described as more effective in enhancing motivation and learner achievement than other types of embedded strategies. The study indicated that relevance strategies increased the meaningfulness of instruction by relating it to personal needs. The study concluded that students that have relevant instruction were more motivated to study than students that had irrelevant materials. As well, students with enhanced relevance strategies are more motivated and perform better than unenhanced materials. Greater motivation and performance was seen in the embedded relevance-enhancing strategies when compared to the intrinsic relevant group.

A study by the U.S. Navy (Parchman, Ellis, Christinaz, & Vogel, 1997) examined the effect of three alternative computer-based type instructions on the achievement and motivation levels of enlisted trainees studying electricity and electronics. The results of the computer-based instruction were compared to the control group which received the existing instructional unit in a traditional classroom with an instructor teaching from a highly structured instructor's guide. After the four days of instruction were completed, achievement was measured using a post-test and the ARCS motivation questionnaire was used to determine the perception of the motivational characteristics of all four types of instruction. Although reported achievement scores of the quantitative knowledge section of the cognitive skills test indicated that all four groups were below the passing grade, there were statistically significant differences in achievement between the instruction types. The achievement scores resulting from the computer based drill and practice instruction (CBDP) and the enhanced computer based instruction (ECBI) were statistically significant compared to the game style instruction (GAME) and the Classroom Instruction (CI). In terms of motivation, the ECBI and GAME were statistically significant for the attention aspect and the group ECBI alone was statistically significant for the confidence aspect as well. There was no significant difference amongst the groups for the relevance or the satisfaction aspects of motivation. The overall significant effects of achievement and motivation with ECBI instruction was attributed to three reasons. The ECBI instruction was described as more task oriented rather than topic oriented as was used in the other computer based instruction and classroom instruction. Secondly, ECBI used visualization techniques and simple simulations that demonstrated cause and effect relationships allowing learners to physically view concepts that otherwise would be invisible. Finally, elaborations used with the ECBI instruction such as graphics and simulations demonstrated the structure and function of concepts and events (Parchman et al., 1997).

Song and Keller (2001) examined the effects of three levels of motivationally adaptive computer assisted instruction. According to Song and Keller (2001), the increased occurrence and use of computer instruction had negatively affected the motivation level associated with the novelty of computer use by students for instructional delivery. In this study, adaptive instruction based on Keller's ARCS model of motivation (1987) in both theory and design, was examined to determine the effectiveness, perceived motivation, efficiency, and continuing motivation of tenth grade participants studying genetics biology. Effectiveness was determined by administering a 13-item posttest based on the content of the instructional materials. Perceived motivation was determined in terms of attention, relevance, confidence, satisfaction, and overall motivation to the instructional material's motivational elements by using a simplified version of Keller's Instructional Material Motivation Survey (IMMS). Efficiency was measured by a ratio of posttest performance to study time used by each participant to study for the quiz. Continuing motivation was measured by asking the participants if they wanted to learn more about the instructional content or similar content in the future (Song & Keller, 2001).

The purpose of motivationally adaptive instruction was to make available suitable types, purposes, and amounts of instructional strategies so as to include learning strategies when learners were demotivated and to exclude unwarranted learning strategies when learners were already highly motivated. Motivational self-assessments were embedded at specific intervals in the lesson that reflected attention, relevance and confidence subcategories while the satisfaction category was addressed at the conclusion of the instruction. In response to the learner's self-assessment results, the computer provided the most suitable motivational strategies (Song & Keller, 2001).

Motivationally saturated instruction included both enhanced and sustainable motivational strategies. Included were a large number of motivational tactics which were expected to annoy and demotivate learners. Motivationally minimized instruction included sustaining instructional strategy tactics. The goal of these strategies was to sustain the motivation of learners and not to either demotivate or improve low motivation. Data indicated that motivationally adaptive CAI resulted in statistically significant results for effectiveness, overall motivation, and attention. There was also a significant difference regarding relevance. Motivationally adaptive CAI showed a higher relevance than motivational saturated CAI. Both the motivational adaptive and motivationally minimized CAI indicated higher efficiency than the motivationally saturated CAI. Data also indicated that there was no statistically significant difference in terms of efficiency between the three types of CAI. There was a significant correlation between overall motivation and continuing motivation across the three CAI types meaning that if the learners are motivated at all that they will continue to be motivated in the future (Song & Keller, 2001).

Kim and Keller (2008) studied the effects of motivational and volitional email messages on achievement, study time, and motivation of undergraduate students. Directing personal attention and providing supportive information to each student via email may lead to improved interaction between students and instructors and would thereby lead to greater motivation resulting in higher academic achievement. According to Kim and Keller (2008), challenges to motivating students in large undergraduate lecture classes included difficulties in establishing personal contact with each student as well as having each student believe that the instructor had addressed their individual needs, interests, and goals.

Difficulty in motivating students poses more of a challenge when the course is a requirement regardless of student interest. Achieving successful grades is dependent upon both extrinsic motivation such as the desire to achieve and intrinsic motivation which is reflected by volition or self-regulation. For example, a student may be extrinsically motivated to achieve a goal of higher grades but may not have enough intrinsic motivation to avoid obstacles that lead to distractions that would interfere with achieving the desired goal (Kim & Keller, 2008).

The intervention utilized in this study included elements of both motivational and volitional strategies and also served the purpose of providing personal attention to individual students. An initial achievement test was administered to all participants and results were reported back to each student along with a short survey regarding course motivation, time spent studying, and satisfaction levels regarding test scores. Those participants that indicated a low satisfaction level with their scores were assigned to receive emails containing specific motivational and volitional strategies reflecting the survey results along with personal messages. Those with high levels of satisfaction were assigned to the group which would receive general motivational and volitional strategies and non-personal emails. Previous studies using emails were focused on course related materials and not on interests, emotions or motivations of the individual student. A second achievement test was administered and the results indicated that the personal message group demonstrated a higher level of motivation (Kim & Keller, 2008).

The motivational aspect of the motivational-volitional strategies reflected the four categories of the ARCS model which are attention, relevance, confidence, and satisfaction. The attention-enhanced message was designed to stimulate attention by the participant by addressing the student by first name. This raised the arousal and curiosity by directly relating the email to the participant. The relevance-enhanced message related the course objectives to the individual participant by incorporating the information provided in the individual audience analysis. The confidence-enhanced message used an approach with the intent of convincing the participant that personal goals could likely be achieved if the strategies were used. The satisfaction-enhanced message approach showed the participant what would be achieved if the strategies were accepted and used (Kim & Keller, 2008).

A second achievement test was administered along with a post-survey on motivation for the course and study time. Motivation was analyzed with scores on interest, relevance, and confidence. Data indicated that participants that received personal email messages had a higher level of motivation and had statistically significant higher levels of confidence than participants that received non-personal email. However, attention and relevance levels did not increase and this result was attributed to the fact that a greater number of words and sentences in the personal message encouraged the confidence rather than relevance and attention. In terms of achievement, the mean scores of the test increased for the personal email group while the mean test scores for the non-personal message group decreased. Study time differences between the two groups were not deemed significantly different (Kim & Keller, 2008).

The study also suggests that the motivational-volitional emails could have also affected the participants' volition to prepare for the second test. These strategies may have had a greater impact on the personal message group since they originally had the lowest satisfaction levels and may have been searching for useful information to increase achievement levels. The non-personal message group did not have a significant impact on the effort of the participants to prepare for the next test. By not having emails with attention tactics, the motivational-volitional emails may not have been as effective. It was suggested that the non-personal message group may have not moved from the commitment stage to the formation of implementation intention and would not have been prepared to transition from the pre-actional phase to the actional phase. This study also suggested that using motivational-volitional emails with personal messages that reflect individual issues may be useful to improve motivation and learning in environments where motivation may be at risk. The study also suggested that a positive effect may be realized where there is little interaction between students and instructors such as large class sizes. This study validated the process of using motivational volitional emails with personal messages (Kim & Keller, 2008).

Summary

This chapter presented a review of research studies of individual and group personalization instruction and the effects on academic achievement and motivation. Positive effects on learner interest, understanding, and achievement were reported for both individual and group personalization of instruction. Personalization is more effective when solving complex two step mathematical word problems and with learners who have lower-level math knowledge. Motivational constructs positively affect learner performance in the mathematics domain. Keller's ARCS model of motivational design addresses four requirements, which are Attention, Relevance, Confidence, and Satisfaction, which has been positively reported to gain and maintain learner motivation.

CHAPTER 3: METHODOLOGY

This section provided an overview of the methodology used in this study which includes a description of the research design, population and sample, instrumentation, data collection procedures, and data analysis. The purpose of the study was to determine the effect of individual personalized mathematical instruction on the achievement of solving mathematical word problems by undergraduates enrolled in postsecondary developmental mathematics course. The study also examined the effect of individual personalized mathematical instruction on undergraduate motivation to solve mathematical word problems.

The following research questions guided this study.

1. What is the effect of individual personalization on learner mathematical knowledge acquisition?
2. What is the effect of individual personalization on learner motivation to solve word problems?
3. What is the effect of individual personalization on long term learner motivation?

Research Design

The design was a true experimental, control group design undertaken using statistical methods (Campbell & Stanley, 1963). The design used convenience sampling of a learner population enrolled in a credit program since only two class sections of that program, taught by the same instructor, was accessible for this study. The main disadvantage of convenience sampling was that the individuals in the sample may not have been representative of the population. In other words, by taking a convenience sample, the population may have been under-represented or over-represented of particular groups which could have undermined the generalization of the sample to the population (Creswell, 2012). Participants were randomly assigned to one of two groups: the experimental group or the control group. All instructional materials were based on the authentic in class instructional materials used in the course Mathematics of Finance. The experimental group received individual personalized mathematical word problem instruction materials. The control group used non-personalized instructional materials.

The design and development of this between-treatment study was based on the premise that a relationship exists between the type of personalized instruction and variables of mathematics achievement and motivation. In other words, the purpose of this experiment was to determine the effect, if any, of individual personalization of instruction on knowledge acquisition and motivation.

Target Population

The target population of this study was adult learners enrolled in a 15 week, mandatory for-credit mathematics course called Mathematics of Finance. This introductory course is a requirement for all first year college business students and must be successfully completed in order to graduate with a college diploma in Business.

The main focus of the course Mathematics of Finance is to develop students' ability to perform basic mathematic operations and to apply mathematical techniques to a wide range of business problems. The individuals in the population were 18 years old or older and historically, enrollment has reflected an approximately equal number of males and females.

Setting

Georgian College is a Canadian post-secondary college established in 1967 during the formation of the province of Ontario's college system. Georgian College is considered one the fastest growing colleges in Ontario offering over 100 programs including degrees, diplomas, graduate certificates, as well as academic upgrading courses in English and mathematics. Approximately 10,000 students attend full-time and 16,000 students attend continuing education courses and programs. The college is comprised of seven campuses located in the counties of Simcoe and Bruce. There are three main campuses: Barrie, Orillia, and Owen Sound; and four regional campuses: Midland, Muskoka, Orangeville, and South Georgian Bay. The course Mathematics of Finance is offered at Georgian College's Barrie campus. One permanent, full-time Georgian instructor facilitates the Mathematics of Finance course for the Barrie campus using existing instructional print modules. The other campuses offering Mathematics of Finance are each taught by other individual instructors who do not use print instructional modules.

The Barrie campus classroom instruction took place in a traditional classroom setting. The classrooms were approximately 40 feet wide by 40 feet long with 6 windows approximately 2 feet wide and 5 feet high. Individual desks were arranged in 5 rows of 9 seats and were able to accommodate 50 students. Facing the desks was a large chalkboard approximately 35 feet wide and 4 feet high at the front of the classroom. Participants completed the unit instruction in the classroom, proctored by the Georgian instructor. There was one door used for both entrance and exit which was closed during testing sessions.

Participants

Permission to conduct this study was obtained through the Business Department at Georgian College. Historically, approximately 200 students in total enroll in the Mathematics of Finance course during the winter semester at the Barrie campus of Georgian College. One individual Georgian instructor facilitated two course sections of Mathematics of Finance. This individual Georgian instructor required all participants to use print instructional modules. All participants were required to complete print instructional modules in the classroom during specific lecture delivery times. There were 74 participants who participated in this study. The experimental group had 35 participants and the control group had 39 participants.

The participants ranged in age from 18 years to over 30 years old. The greatest frequency of age range was between the ages of 18 to 21 years old, followed by the age range of 22 to 25 years of age. The least frequency of age range was between the ages of 26 to 29 years of age. The participants were enrolled in the Business Program and required this for credit course in order to complete the program.

Instrumentation

Information regarding individual and group favorites was gathered using the Favorites List. Data was collected using quantitative instruments to measure mathematical achievement and motivation. The instruments are described below.

Favorites List

The Favorites List of 18 questions was administered to the participants in print form during the first week of instruction by me. The Favorites List was used to gather information provided by the participant regarding personal favorites such as favorite foods and activities. The first column in the Favorites List is the 'Your Favorite' gathered the personal favorites of those participants in the experimental group. The items in the Favorites List are based on similar items used in other personalization studies such as Akinsola and Awofala (2009), Ku et al. (2007), Lopez and Sullivan (1991, 1992), and Anand and Ross (1987). The response to the request for Favorites List items identified those objects, places, and people considered as a favorite or best liked. The Favorites List was presented in Appendix B.

Word Problem Instruction

Two types of print instructional modules corresponded to the two groups (experimental, control) were administered to the participants who were randomly assigned to their respective treatment groups during the first week of class. The treatment versions of the instructional modules were based on the actual instructional module, used in the Mathematics of Finance course. The instructional module dealt with solving cash discount word problems. According to Georgian College's policy concerning confidentiality of instructional materials, the actual instruction cannot be replicated outside of classroom use.

The control group instruction was based on the standard course instruction without any modifications. The experimental group instruction was created by embedding the standard instruction with personal information based on the results from the Favorites List. Examples for the two types of instructions were presented in Appendix C.

Post-Instructional Test

The post-instructional test was based on the standard course test which included five algebraic word problems. The control group test reflected the standard text-book based test. The experimental group test incorporated the Favorites List responses with the five algebraic word problems. According to Georgian College's policy concerning confidentiality of instructional materials, actual test materials cannot be replicated outside of classroom use. Examples for the two types of test questions were presented in Appendix D.

Motivation Survey

Instructional Materials Motivation Survey (IMMS), based on Keller's ARCS Model (Keller, 1987a), was designed to measure reactions to self-directed instructional materials in terms of Attention, Relevance, Confidence, and Satisfaction (ARCS). Attention considers the learner interest that is gained and maintained during educational activities. Relevance considers the learner perception regarding the educational activity as it relates to a personal need or want. Confidence reflects the learner's expectation to succeed at the activity. Satisfaction refers to the learner's anticipation of rewards from the activity (Keller, 2010). According to Keller (2010), the goal of IMMS was to measure motivation levels of students towards a specific course rather than generalized levels of motivation towards learning in general. The 36-item IMMS was administered to participants immediately after the completion of instructional units 1, 2, and 3. IMMS was presented in Appendix E. Permission to use the IMMS free of charge was granted by the author of the survey and was presented in Appendix G.

The 36 items in the survey were designed to correspond to the motivational concepts and theories of the ARCS Model (1987a). Keller (2010) stated that the IMMS was suitable for undergraduate students. It offered flexibility in the wording to reflect specific conditions or situations such as:

- "this lesson",
- "this workshop",
- "this course",
- "this lecture",
- "this computer based instruction" (Keller, 2010, p. 10).

There are 12 items for the subscale Attention, nine items each for the subscales Relevance and Confidence, and six items for the subscale Satisfaction for a total of 36 items. Keller (2010) attributed the greater number of items for the Attention scale compared to the other subscales as a means to properly weigh boredom and lack of stimulation common to instructional writing. As well, the Satisfaction scale reflects fewer items compared to the other subscales due to the satisfaction category not having as many "points of connection" (Keller, 2010, p. 11).

The IMMS was scored for the four individual subscales of Attention, Relevance, Confidence, and Satisfaction as well as for the total score of all four subscales. The minimum possible score for the IMMS is 36, maximum score is 180, and the mid-point is 108. A 5-point Likert-type scale was used where 1 = *not true*, 2 = *slightly true*, 3 = *moderately true*, 4 = *mostly true*, and 5= *very true*. According to the IMMS Scoring Guide, statements 12, 15, 22, 29, 31, 26, 3, 7, 19, and 34 were stated in a negative manner, so for analysis, scores were reverse coded; that is, 5=1, 4=2, 3=3, 2=4, and 1=5. The scoring guide was presented in Appendix F.

The IMMS reliability estimates were deemed satisfactory based on Cronbach's alpha with reliability estimated for Attention (α = 0.89), Relevance (α = 0.81), Confidence (α = 0.90), Satisfaction (α = 0.92), and for the total scale (α = 0.96) (Keller, 2010). The validity of the IMMS was tested by randomly assigning learners to a control or a treatment group (Keller, 2010). The control group received instruction that was designed according to standard principles and was not enhanced with instructional design. The treatment group received enhanced instruction designed to arouse curiosity and attentiveness, demonstrate practical relevance, promote confidence, and offer satisfying results. The treatment group test scores were significantly greater than those of the control group (Keller, 2010).

Data Collection

Data was collected for this study using the following print instruments: Favorites List, instructional units in non-personalized form and individual personalized form, module tests in non-personalized form and individual personalized form, and IMMS to measure motivation. Random numbers were generated using Excel and then assigned to the two groups, the experimental group and the control group, and then recorded using electronic file storage. The Excel spreadsheet file was kept confidential and secured in a locked cabinet in a locked room accessible only by me. These assigned random numbers were uniquely paired to alphanumeric codes in order to ensure that participants were not aware of which group they had been randomly assigned to. For example, a random number of 10 was paired with the alphanumeric code AT1X0Q. The unique alphanumeric codes were used to identify each participant and corresponding instruments.

During the first week of instruction, I provided the information sheet along with an alphanumerically coded Favorites List. The information sheet was presented in Appendix A. Participants' return of completed Favorites Lists indicated consent, and those participants' names and alphanumeric codes were recorded in a ledger book by me. I maintained confidentiality of the names and assigned codes and securely stored the ledger in a locked cabinet in a locked room. I entered the information from the Favorites List on the Excel spreadsheet. Information in the 'Your Favorites' column from the Favorites List for those participants assigned to the experimental group was embedded in the Week 2 instructional module and test using the mail merge option available in the Microsoft Word program. The control group received standard textbook based instruction and test.

The instructional modules and tests and IMMS for the experimental group and control group were printed on a Xerox brand laser printer. Each instructional module and test and IMMS was identified using an alphanumeric code. The instructional modules and tests and IMMS were delivered to the Georgian instructor and kept in a secure locked file. When a participant identified readiness to complete the instructional module and test, the Georgian instructor then gave the instruction to the participant during class lecture time. After completing the instructional module, the participant contacted the Georgian instructor to indicate readiness for the module test.

The instructional module test took place in the classroom, proctored by the Georgian instructor. After the participant completed the test, the Georgian instructor collected the test and then gave the IMMS to the participant to complete. Once the IMMS was completed, the Georgian instructor collected them. The Georgian instructor then gave me the completed tests and IMMS. I copied the completed tests and submitted a copy without the alphanumerical codes back to the Georgian instructor for grading. These were the same steps taken for Weeks 2 and 3.

The standard course test was used to create tests for the experimental group and control group. The standard course test was comprised of five algebraic word problems. The experimental group and the control group each included five test algebraic word problems. Each of the five algebraic word problem test questions was scored out of three grade points. Each algebraic word problem test question was assigned one point for each the following activities: attempt to solve, correct translation of unknown and known, and correct computation. The test scores for the word problems were scored out of 15.

I graded all the test questions and recorded the participants' test results in a ledger that was secured in a locked cabinet. Test values were then transferred from the ledger to the Excel spreadsheet. Responses of the IMMS were also transferred to the ledger and then the total IMMS total score recorded in an Excel spreadsheet. Table 1 presented a summary of research questions, statistical analysis method, corresponding variables and covariates. The independent variable, covariate, and dependent variable referred to components of ANCOVA and profile analyses.

Table 1

Summary of Data Analysis Plan for Research Questions 1 - 3

RQ	Description	Independent Variable	Statistical Analysis	Covariate	Dependent Variable
1	What is the effect of individual personalization on learner mathematical knowledge acquisition?	Group Type (Experimental, Control)	ANCOVA Profile Analysis	Math Knowledge Acquisition (Module Test 1)	Math Knowledge Acquisition (Module Test 2) Math Knowledge Acquisition (Module Tests 1-3)
2	What is the effect of individual personalization on learner motivation to solve word problems?	Group Type (Experimental, Control)	ANCOVA Profile Analysis	Learner Motivation (IMMS 1)	Learner Motivation (IMMS 2) Learner Motivation (IMMS 1-3)
3	What is the effect of individual personalization on long term learner motivation?	Group Type (Experimental, Control)	ANCOVA Profile Analysis	Learner Motivation (IMMS 1)	Long Term Learner Motivation (IMMS 3) Learner Motivation (IMMS 1-3)

Summary

Chapter three outlined the research design, target population, setting, target population, participants, instrumentation, data collection, and data analysis table for this study. The research design was a true experimental, post-test only, control group design. The study took place in an authentic classroom with participants enrolled in a for-credit mathematics course. The study took place over a three week time period.

The instruments used were a Favorites List, weekly instruction modules and tests, and IMMS. Chapter four presented detailed results of the analyses.

CHAPTER 4: RESULTS

This chapter presents the results relevant to the three research questions. Data was collected during a three week period using authentic course module units and tests. Week 1 data was collected from control and experimental groups administered Instructional Module 1 and test in non-personalized form and the IMMS 1 survey. Week 2 data was collected from the control group administered Instructional Module 2 and test in non-personalized form and IMMS 2 while the experimental group was administered Instructional Module 2 and test in personalized form and IMMS 2. Week 3 data was collected from control and experimental groups administered Instructional Module 3 and test in non-personalized form and the IMMS 3.

Data Analysis Procedure

Inferential statistics were used to draw conclusions from the sample tested. The Statistical Package for the Social Sciences (SPSS) was used to code and tabulate scores collected from the module tests and IMMS, and provide summarized values where applicable including the mean and standard deviation (Norusis, 2011). Demographic data was processed using frequency statistics. Analyses of covariance (ANCOVA) and profile analyses were used to assess the three research questions. The research questions were:

Research Question 1 (RQ1): What is the effect of individual personalization on learner mathematical knowledge acquisition?

Research Question 2 (RQ2): What is the effect of individual personalization on learner motivation to solve word problems?

Research Question 3 (RQ3): What is the effect of individual personalization on long term learner motivation?

Table 4.1

Study Variables and Statistical Test Used to Evaluate Three Research Questions

Hypothesis	Dependent Variable	Independent Variable	Analysis
1	Mathematical Knowledge Acquisition	Group Type	ANCOVA, Profile Analysis
2	Learner Motivation	Group Type	ANCOVA, Profile Analysis
3	Long Term Learner Motivation	Group Type	ANCOVA, Profile Analysis

Prior to analyzing the three research questions, data hygiene and data screening were completed to make sure that the variables of interest met appropriate statistical assumptions. The following analyses followed a similar analytic strategy in that the variables were first evaluated for missing data and univariate outliers, normality and homogeneity of variance. Next, ANCOVAs were run to determine whether differences existed between groups in week 2, when the experimental group was administered personalized instructional materials and module tests, after controlling for week 1.

Profile analyses were then run to determine if differences existed between groups across weeks.

Demographics

The sample population of adult learners was 18 years and older and were enrolled in a first year developmental mathematics course required for successful completion of a college diploma in Business. The participants were randomly assigned into two groups: experimental and control. The experimental group received personalized instruction and personalized testing while the control group received standard non-personalized course instruction and testing. The largest age group for both experimental and control groups were 18-21 years old. Table 4.2 displayed the age demographics of the participants in the experimental and control groups.

Table 4.2

Count and Percent Statistics for Participant Age by Group Type

Group Type	Age	Frequency	Percent
Experimental	18-21	24	68.6
	22-25	7	20.0
	26-29	2	5.7
	30+	2	5.7
Control	18-21	20	51.3
	22-25	12	30.8
	26-29	2	5.1
	30+	5	12.8

Note. Total $n = 74$.

Research Question 1

Null Hypothesis 1 ($H1_0$): There is no significant difference in mathematical knowledge acquisition between group types (experimental, control).

Alternative Hypothesis 1 ($H1_A$): There is a significant difference in mathematical knowledge acquisition between group types (experimental, control).

Hypothesis 1 was tested using ANCOVA to determine whether mathematical knowledge acquisition differed between experimental and control groups in week 2 after controlling for week 1. Mathematical knowledge acquisition was measured by three module tests. Differences between experimental and control groups across the three weeks were examined by running a profile analysis. The independent variable for Hypothesis 1 was group type (experimental, control). The experimental group was administered non-personalized instructional materials and non-personalized module tests in weeks 1 and 3. The experimental group was administered personalized instructional materials and personalized module test in week 2 only. The control group had non-personalized instructional materials and non-personalized module tests for weeks 1, 2, and 3. The dependent variable was module test 2 scores, while the covariate was module test 1 scores.

Data cleaning. A test for univariate outliers was conducted by converting observed scores to z-scores and then comparing case values to the critical value of ±3.29 ($p < .001$) (Tabachnick & Fidell, 2007). Case z-scores that exceed this value are greater than three standard deviations from the normalized mean. No univariate outliers were found. Missing data were investigated by running frequency counts in SPSS 20.0. For cases in which responses to 5% or less of the items were missing, values were replaced with item means calculated across all participants. Seven participants did not complete module test 2, and therefore were excluded for ANCOVA. An additional 11 participants did not complete module test 3 and were also excluded from profile analysis. Therefore, for the ANCOVA to test Hypothesis 1, data from 74 students were collected and 67 were entered into the model (n = 67). For the profile analysis, 56 were entered into the model (n = 56). Descriptive statistics for mathematical knowledge acquisition by module test and group type were displayed in Table 4.3.

Table 4.3

Descriptive Statistics for Mathematical Knowledge Acquisition by Module Test and Group Type

Module Test	Group Type	n	Min	Max	Mean	Std. Dev.	Skew	Kurtosis
1	Experimental	29	6	15	13.17	2.205	-1.866	3.735
	Control	27	7	15	12.48	2.327	-0.835	-0.195
2	Experimental	29	5	15	13.48	2.811	-2.058	3.386
	Control	27	5	15	12.30	3.484	-0.905	-0.753
3	Experimental	29	7	15	12.48	2.600	-0.588	-0.880
	Control	27	4	15	11.59	3.079	-0.882	-0.157

Tests of normality. Before Hypothesis 1 was analyzed, basic parametric assumptions of normality were assessed for the dependent variable, mathematical knowledge acquisition, which was measured by the module tests 1-3. To test if the distributions for the two groups (experimental, control) were significantly skewed across each of the three quizzes, the skew coefficients were divided by the skew standard error resulting in z-skew coefficients. This technique was recommended by Tabachnick and Fidell (2007). Specifically, *z*-skew coefficients exceeding the critical value of ±3.29 (p <.001) may indicate non-normality. Thus, based on the evaluation of the *z*-skew coefficients, scores for module tests 1 and 2 were found to be negatively skewed for the experimental group. Z-kurtosis was also evaluated using the same technique and scores for module tests 1 and 2 for the experimental group were found to be kurtotic. Therefore, a Log10 transformation was conducted on module tests 1 and 2. Module test 3 scores were not transformed, but were standardized to *z*-scores for the data analysis.

Table 4.4

Normality Statistics of Mathematical Knowledge Acquisition by Module Test and Group Type

Module Test	Group	Skewness	Skew Std. Error	z-Skew	Kurtosis	Kurtosis Std. Error	z-Kurtosis
1	Experimental	-1.866	0.448	-4.165	3.735	0.872	4.283
	Control	-0.835	0.434	-1.924	-0.195	0.845	-0.231
2	Experimental	-2.058	0.448	-4.594	3.386	0.872	3.883
	Control	-0.905	0.434	-2.085	-0.753	0.845	-0.891
3	Experimental	-0.588	0.448	-1.313	-0.880	0.872	-1.009
	Control	-0.882	0.434	-2.032	-0.157	0.845	-0.186

Note. Skew std. error = 0.441; Kurtosis std. error = 0.858.

Homogeneity of variance. Levene's test was run to determine if the error variance of the dependent variable was equal across groups. Results from the test indicated that the distribution for module test 1 and 3 met the assumption of homogeneity of variance. However, module test 2 did not meet the assumption of homogeneity. Since a non-parametric test does not exist for this research design, results were reported despite this limitation.

Table 4.5

Levene's Test of Equality of Error Variances for Hypothesis 1

Module Test	*F*	df1	df2	Sig.
1	.002	1	54	.968
2	5.300	1	54	.025
3	.647	1	54	.425

Results of research question 1. Analysis of covariance (ANCOVA) was used to test whether or not there was a significant difference in module test 2 scores between group types after taking into account module test 1 scores. Results indicated that after taking into account scores for module test 1, the difference in scores for module test 2 between the experimental and control group was not statistically significant; F (1, 57) = 1.277, p = .263, *partial eta- squared* = .020 – see Table 4.6 for summary details. Thus, the null hypothesis for Research Question 1 was retained.

Table 4.6

Model Summary Generated from ANCOVA Analysis

Source	Type III Sum of Squares	df	Mean Square	*F*	Sig.	*Partial Eta Squared*
Corrected Model	3.111	2	1.556	14.431	< .001	.311
Intercept	0.990	1	0.990	9.184	.004	.125
Module Test 1	2.769	1	2.769	25.691	< .001	.286
Group Type	0.138	1	0.138	1.277	.263	.020
Error	6.898	64	0.108			
Total	40.945	67				
Corrected Total	10.010	66				

Note. n = 67, Post-hoc power = .053, sample size necessary for 80% power = 19,625
F tests - ANCOVA: Fixed effects, main effects and interactions
Analysis: A priori: Compute required sample size
Input: Effect size f = 0.020

α err prob = 0.05
Power (1-β err prob) = 0.80
Numerator df = 1
Number of groups = 2
Number of covariates = 1
Output: Noncentrality parameter λ = 7.8500000
Critical F = 3.8419328
Denominator df= 19622
Total sample size = 19625
Actual power = 0.8000185

Additional analysis. Using SPSS 20.0, profile analysis was conducted to evaluate Research Question 1. Profile analysis assesses differences between control and experimental groups in two ways: between-subjects analysis and a multivariate test. Between-subjects analysis evaluates differences in the average of the three module test scores between control and experimental groups, and the multivariate test evaluates whether or not the groups' profiles differ across the three module tests.

Results from the between-subjects analysis indicated that no significant difference existed in the average of three module test scores between groups; F (1, 54) = 2.064, p = .157, *partial eta squared* = .037 – see Table 4.7 for summary details. The mean score across all three module tests for the control group (M = 12.12, SD = 2.436) was not significantly different than the experimental group (M = 13.04, SD = 2.185).

Table 4.7

Results for Between-Subjects Analysis for Hypothesis 1

Source	Type III Sum of Squares	df	Mean Square	*F*	Sig.	*Partial Eta Squared*	Observed Power
Intercept	33.955	1	33.955	49.134	<.001	.476	1.000
Group	1.426	1	1.426	2.064	.157	.037	.292

Type			
Error	37.318	54	0.691

Note. Dependent variable: Mathematical Knowledge Acquisition, Post-hoc Power = .292, minimum sample size necessary for 80% power = 1,176

F tests - ANOVA: Repeated measures, within-between interaction
Analysis: A priori: Compute required sample size
Input: Effect size f = 0.037
α err prob = 0.05
Power (1-β err prob) = 0.80
Number of groups = 2
Number of measurements = 3
Corr among rep measures = 0.5
Nonsphericity correction ε = 1
Output: Noncentrality parameter λ = 9.6596640
Critical F = 2.9995577
Numerator df = 2.0000000
Denominator df= 2348
Total sample size = 1176
Actual power = 0.8005516

The multivariate test indicated that no significant differences existed between group profiles across the three module tests; *Wilks' Lambda* = 0.984, *F* (2, 53) = 0.432, *p* = .651, *partial eta squared* = .016. As the control group's scores decreased from module test 1 (*M* = 12.48, *SD* = 2.327) to module test 2 (*M* = 12.30, *SD* = 3.484), the experimental group's scores increased from module test 1 (*M* = 13.17, *SD* = 2.205) to module test 2 (*M* = 13.48, *SD* = 2.811). However, it was not a significant difference. As the control group's scores decreased from module test 2 to 3 (*M* = 11.59, *SD* = 3.079), the experimental group's scores decreased from module test 2 to 3 (*M* = 12.48, *SD* = 2.600). A means plot of experimental and control groups' mean scores across the three modules were displayed in Figure 4.1.

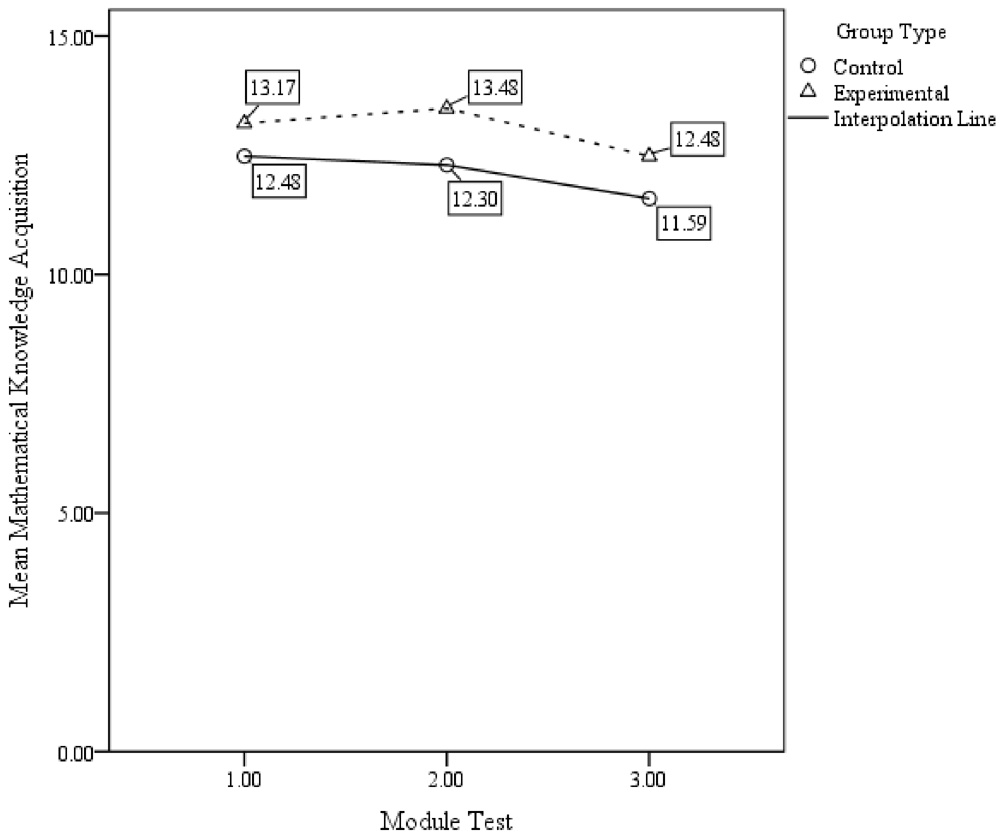

Figure 4.1. Means plot of module test scores by experimental and control groups

Research Questions 2 and 3

Null Hypothesis 2 ($H2_0$): There is no significant difference in learner motivation to solve word problems between group types (experimental, control).

Alternative Hypothesis 2 ($H2_A$): There is a significant difference in learner motivation to solve word problems between group types (experimental, control).

Null Hypothesis ($H3_0$): There is no significant difference in long term learner motivation between group types (experimental, control).

Alternative Hypothesis ($H3_A$): There is a significant difference in long term learner motivation between group types (experimental, control).

Hypothesis 2 and 3 were tested using ANCOVAs and a profile analysis to determine whether learner motivation, measured by IMMS 1-3 , differed between group type (experimental, control). For the ANCOVA used to test Hypothesis 2, the dependent variable, learner motivation, was measured in week 2 (IMMS 2) while the independent variable was group type (experimental, control). The covariate was learner motivation measured in week 1 (IMMS 1).

For the ANCOVA used to test Hypothesis 3, the dependent variable was long term learner motivation, measured in week 3 (IMMS 3), while the independent variable was group type (experimental, control), and the covariate was learner motivation measured in week 1 (IMMS 1).

Data cleaning. A test for univariate outliers was conducted by converting observed scores to z-scores and then comparing case values to the critical value of ±3.29, $p < .001$ (Tabachnick & Fidell, 2007). Case z-scores that exceed this value are greater than three standard deviations from the normalized mean. No univariate outliers were found. Missing data were investigated by running frequency counts in SPSS 20.0. For cases in which responses to 5% or less of the items were missing, values were replaced with item means calculated across all participants. Seven participants did not complete

IMMS 2, and therefore were excluded for ANCOVA. An additional 11 participants did not complete IMMS 3 and were also excluded from profile analysis. Therefore, for the ANCOVA to test Hypothesis 2, data from 74 students were collected and 67 were entered into the model (n = 67). For the ANCOVA to test Hypothesis 3, data from 74 students were collected and 60 were entered into the model (n = 60). For the profile analysis for Hypothesis 2 and 3, data from 74 students were collected and 56 were evaluated (n = 56). Descriptive statistics for learner motivation by group type are displayed in Table 4.8.

Table 4.8

Descriptive Statistics for Learner Motivation by IMMS and Group Type

IMMS	Group Type	*n*	Min	Max	Mean	Std. Dev.	Skew	Kurtosis
1	Experimental	28	1.92	4.58	3.57	0.567	-0.795	1.270
	Control	28	2.17	4.50	3.37	0.587	-0.264	-0.021
2	Experimental	28	2.18	4.75	3.42	0.604	0.104	-0.162
	Control	28	1.53	4.53	3.06	0.677	0.196	0.741
3	Experimental	28	1.89	4.22	3.23	0.592	-0.707	0.269
	Control	28	1.53	4.64	3.10	0.772	0.001	-0.341

Tests of normality. Before Research Questions 2 and 3 were analyzed, basic parametric assumptions of normality were assessed for the dependent variable (learner motivation). In order to test if the distribution was significantly skewed for the two groups and for each of the three IMMS scores, the skew coefficient was divided by the skew standard of error resulting in a z-skew coefficient. This technique was recommended by Tabachnick and Fidell (2007). Z-skew coefficients exceeding the critical value of ±3.29 (p <.001) may indicate non-normality. Based on the evaluation of the z-skew coefficients, no variables were significantly skewed. Z-kurtosis was also evaluated using the same technique and none of the variables were found to be significantly kurtotic.

Table 4.9

Skewness and Kurtosis Statistics of Learner Motivation by Group Type and IMMS

IMMS	Group	Skewness	z-Skew	Kurtosis	z-Kurtosis
1	Experimental	-0.795	-1.803	1.270	1.480
	Control	-0.262	-0.594	-0.007	-0.008
2	Experimental	0.104	0.236	-0.161	-0.188
	Control	0.195	0.442	0.737	0.859
3	Experimental	-0.710	-1.610	0.277	0.323
	Control	0.003	0.007	-0.338	-0.394

Note: Skew std. error = 0.441; Kurtosis std. error = 0.858

Homogeneity of variance. Homogeneity of variance was evaluated using Levene's Test of Equality of Error Variance to determine if the error variance of the dependent variable was equal across groups (Experimental, Control). Results from the test indicated that the distribution of the dependent variables (IMMS 1-3) did meet the assumption of homogeneity of variance. Levene's Test indicated that the distributions of the transformed scores for all three IMMS met the assumption of homogeneity of variance - see Table 4.10 for details.

Table 4.10

Levene's Test of Equality of Error Variances for IMMS 1 - 3

IMMS	*F*	df1	df2	Sig.
1	0.002	1	54	.961
2	0.091	1	54	.764
3	2.044	1	54	.159

Results of research questions 2. Analysis of covariance (ANCOVA) was used to test whether or not there was a significant difference in learner motivation between groups in week 2 after controlling for week 1. Results indicated that after controlling for IMMS 1 scores, the difference in IMMS 2 between the experimental and control group was statistically significant; F (1, 64) = 5.919, p = .018, *partial eta squared* = .085 – see Table 4.11 for summary details. In week 2, when the experiment group was administered personalized instructional materials and test, there was a significant difference in learner motivation between the experimental and control groups, after controlling for week 1 learner motivation scores. *Partial eta-squared* indicated a medium effect size. Thus, the null hypothesis for Research Question 2 was rejected in favor of the alternative hypothesis.

Table 4.11

Model Summary Generated from ANCOVA Analysis

Source	Type III Sum of Squares	*df*	Mean Square	*F*	Sig.	*Partial Eta-Squared*
Corrected Model	14.048	2	7.024	24.898	< .001	.438
Intercept	1.142	1	1.344	4.766	.033	.069
IMMS 1	8.424	1	10.222	36.234	< .001	.361
Group Type	0.018	1	1.670	5.919	.018	.085
Error	17.998	64	0.282			
Total	616.515	67				
Corrected Total	26.714	66				

Note. Dependent Variable: IMMS 2; *n* = 67, Post-hoc power = .085, sample size necessary for 80% power = 1,089.

F tests - ANCOVA: Fixed effects, main effects and interactions
Analysis: A priori: Compute required sample size
Input: Effect size f = 0.085
α err prob = 0.05
Power (1-β err prob) = 0.80
Numerator df = 1
Number of groups = 2
Number of covariates = 1
Output: Noncentrality parameter λ = 7.8680250
Critical F = 3.8500357
Denominator df= 1086
Total sample size = 1089
Actual power = 0.8002622

Additional analysis. Profile analysis assesses differences between control and experimental groups in two ways: a multivariate test and between-subjects analysis. As exploratory analysis, profile analysis was conducted for Research Questions 2 and 3. The multivariate test evaluates whether or not the groups' profiles differ across the three IMMS scores. The between-subjects analysis evaluates differences in the average of the three IMMS scores between control and experimental groups.

The multivariate test indicated that no significant differences existed between group profiles across the three IMMS scores; *Wilks' Lambda* = 0.966, *F* (2, 53) = 0.940, *p* = .397, *partial eta squared* = .034. That is, as the control group's scores decreased from IMMS 1 (*M* = 3.37, *SD* = 0.587) to IMMS 2 (*M* = 3.06, *SD* = 0.677), the experimental group's scores decreased from IMMS 1 (*M* = 3.57, *SD* = 0.567) to IMMS 2 (*M* = 3.42, *SD* = 0.604). As the control group's scores increased from IMMS 2 to IMMS 3 (*M* = 3.10, *SD* = 0.772), the experimental group's scores decreased from IMMS 2 to IMMS 3 (*M* = 3.23, *SD* = 0.592). A means plot of experimental and control groups' mean IMMS scores across the three modules were displayed in Figure 4.2.

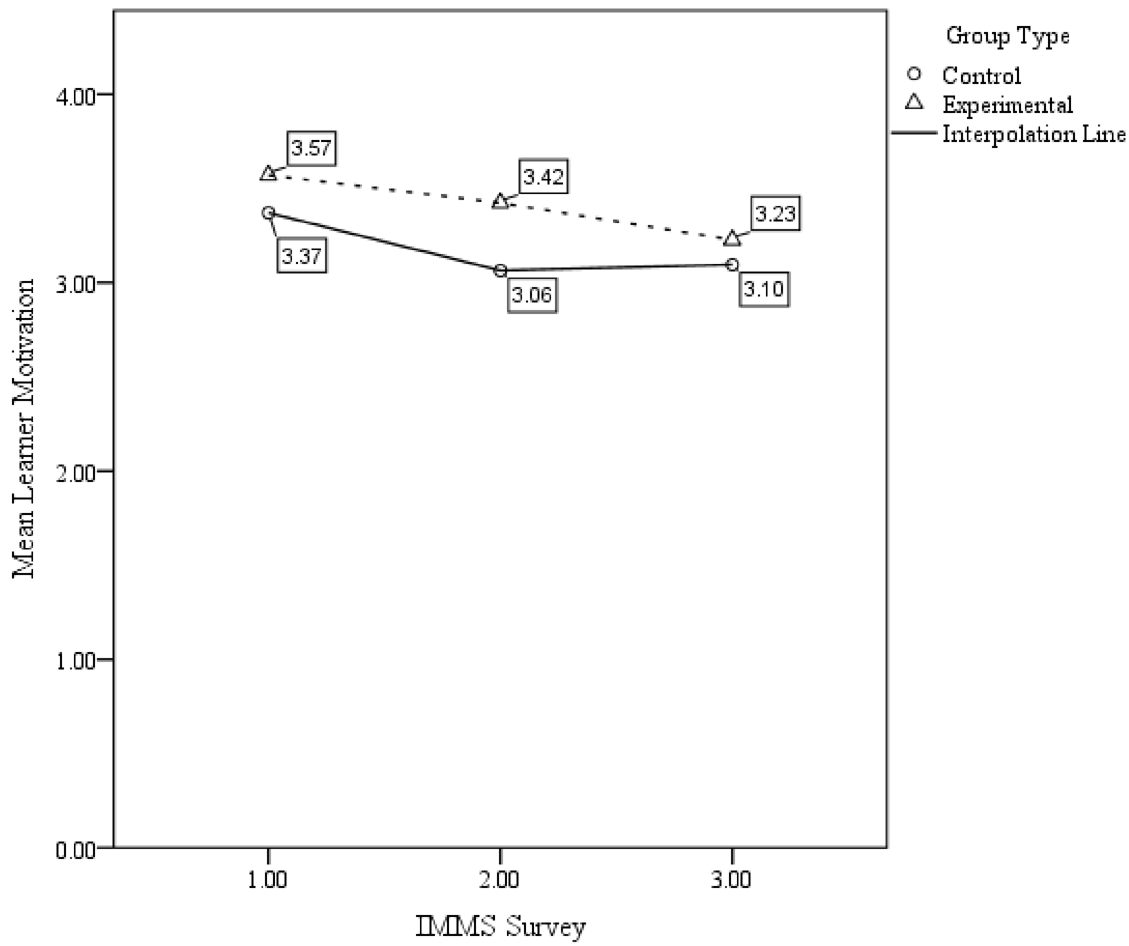

Figure 4.2. Means plot IMMS scores by experimental and control groups

Results from the between-subjects analysis indicated that no significant difference existed in the average of three motivation scores between groups; F (1, 54) = 2.586, p = .114, *partial eta squared* = .046 – see Table 4.12 for summary details. On average the control group (M = 3.18, SD = 0.588) did not score significantly different than the experimental group (M = 3.41, SD = 0.479).

Table 4.12

Summary of Results for Between-Subjects Analysis

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	*Partial Eta Squared*	Observed Power
Intercept	1820.699	1	1820.699	2106.57	.000	.975	1.000
Group Type	2.235	1	2.235	2.586	.114	.046	0.352
Error	46.672	54	0.864				

Note. Dependent variable: Mathematical Knowledge Acquisition, Post-hoc Power = .352, minimum sample size necessary for 80% power = 762.

F tests - ANOVA: Repeated measures, within-between interaction

Analysis: A priori: Compute required sample size

Input: Effect size f = 0.046

α err prob = 0.05

Power (1-β err prob) = 0.80

Number of groups = 2

Number of measurements = 3

Corr among rep measures = 0.5

Nonsphericity correction ε = 1

Output: Noncentrality parameter λ = 9.6743520

Critical F = 3.0016443

Numerator df = 2.0000000

Denominator df= 1520

Total sample size = 762

Actual power = 0.8008976

Results of research questions 3. Analysis of covariance (ANCOVA) was used to test whether or not there was a significant difference in learner motivation in week 3, after controlling for week 1. In week 3, the experimental group returned to non-personalized instructional materials, after having received personalized instructional materials in week 2. Therefore, Research Question 3 was answered by testing whether a difference in IMMS 3 scores existed between experimental and control groups after controlling for IMMS 1 scores.

Results from the ANCOVA indicated that after controlling for IMMS 1 scores, the difference in IMMS 3 between the experimental and control group was not statistically significant; F (1, 57) = 0.056, p = .814, *partial eta-squared* = .001 – see Table 4.13 for summary details. That is, there was no significant difference in learner motivation in week 3 of the experimental and control groups after controlling for learner motivation measured in week 1. The significant difference of learner motivation found in week 2, when the experimental group was administered personalized instructional materials, was not sustained in week 3, when the experimental group was again administered the non-personalized instructional materials.

Table 4.13

Model Summary Generated from ANCOVA Analysis

Source	Type III Sum of Squares	*df*	Mean Square	*F*	Sig.	*Partial Eta-Squared*
Corrected Model	8.716	2	4.358	13.802	< .001	.326
Intercept	1.142	1	1.142	3.616	.062	.060
IMMS 1	8.424	1	8.424	26.678	< .001	.319
Group Type	0.018	1	0.018	0.056	.814	.001
Error	17.998	57	0.316			
Total	616.515	60				
Corrected Total	26.714	59				

Note. Dependent Variable: IMMS 3; n = 60, Post-hoc power = .001, sample size necessary for 80% power = 7,848,863

F tests - ANCOVA: Fixed effects, main effects and interactions

Analysis: A priori: Compute required sample size

Input: Effect size f = 0.001

α err prob = 0.05

Power (1-β err prob) = 0.80

Numerator df = 1

Number of groups = 2

Number of covariates = 1

Output: Noncentrality parameter λ = 7.8488630
Critical F = 3.8414600
Denominator df= 7848860
Total sample size = 7848863
Actual power = 0.8000000

Summary

Results for Research Question 1 indicated there was no difference in mathematical knowledge acquisition between group type (experimental, control) in week 2 after controlling for week 1. Accordingly, the null hypothesis for Research Question 1 was retained. For Research Question 2, a significant difference in learner motivation was found between group type. Results of the ANCOVA indicated there was a significant difference in learner motivation between group types in week 2 after controlling for week 1. Accordingly, the null hypothesis for Research Question 2 was rejected in favor of the alternative hypothesis. However, for Research Question 3, results from the ANCOVA indicated there was no significant difference in learner motivation between group types in week 3 after controlling for week 1. That is, the significant difference found in learner motivation at the end of week 2 with the administration of personalized instructional materials and module tests to the experimental group were not sustained into week 3 after the experimental group returned to non-personalized instructional materials and module tests. Accordingly, the null hypothesis for Research Question 3 was retained.

CHAPTER 5: DISCUSSION AND CONCLUSIONS

A nation's ready supply of human capital is vital for global economic success. Technological demands of the global marketplace require these individuals, who are typically college graduates, to have a requisite mathematical knowledge in order to problem solve effectively. However, many learners struggle with the subject of mathematics as indicated by the report that more than half of the adult population in Canada was scored by experts as below minimum levels for coping with the emerging knowledge in both numeracy and problem solving (OECD, 2005).

The review of the literature indicates positive effects for both individual and group personalization of word problem instruction on mathematical achievement, interest, and motivation (Akinsola & Awofala, 2009; Anand & Ross, 1987; Davis-Dorsey et al., 1991; Hart, 1996; Ku & Sullivan, 2002; Lopez & Sullivan, 1991, 1992). Personalization was specifically effective for solving complex two-step problems (Lopez & Sullivan, 1992) and for those learners who have lower-level mathematics knowledge (Ku, Harter, Liu, Thompson, & Cheng, 2007). Although positive benefits of personalization have been reported for learners enrolled in upper elementary, middle, and senior grades, no studies have been conducted at the college level.

The purpose of this study was to examine the effect of individual personalized mathematical instruction on achievement of solving mathematical word problems among college learners. Mathematical knowledge acquisition and motivation were evaluated to determine if differences existed in these variables between those learners provided with personalized educational materials and those learners provided with standard educational materials. A better understanding of the effect of personalized educational materials on mathematical acquisition and motivation may benefit those struggling learners enrolled in college level mathematics and play a positive role in college graduation rates. The research questions for this study were:

Research Question 1 (RQ1): What is the effect of individual personalization on learner mathematical knowledge acquisition?

Research Question 2 (RQ2): What is the effect of individual personalization on learner motivation to solve word problems?

Research Question 3 (RQ3): What is the effect of individual personalization on long term learner motivation?

The three research questions were answered through analysis of quantitative data collected from a sample of 74 participants. Participants were enrolled in a 15-week course called Mathematics of Finance at Georgian College, located in the province of Ontario, Canada. Participants were randomly assigned to one of two groups: experimental and control. The experimental group was administered personalized and non-personalized educational materials and the control group received standard educational materials. Data from module tests and IMMS were collected and analyzed over a three week period. The module instruction and test administered to participants in the experimental group in Week 2 were individually personalized while the control group was administered standard module instruction and tests for all three weeks. The IMMS administered to both groups were identical.

Summary of Findings

The three research questions were answered using quantitative analysis. To address Research Questions 1 through 3, analyses of covariance and profile analyses were conducted. Research Question 1 was used to assess whether there were differences in mathematical knowledge acquisition between group types. Research Questions 2 and 3 were used to assess whether there were differences in learner motivation. Full details of these analyses were presented in Chapter 4.

Research Question 1 (RQ1): What is the effect of individual personalization on learner mathematical knowledge acquisition?

Results from the analysis of covariance (ANCOVA) indicated that after taking into account scores for module test 1, there was no significant difference in scores for module test 2 between the experimental and control group. Profile analysis was conducted for further assessment of Research Question 1. Results from the between-subjects analysis indicated that no significant difference existed in the average of three test scores between groups. The multivariate test indicated that no significant differences existed between group profiles across the three module tests.

Research Question 2 (RQ2): What is the effect of individual personalization on learner motivation to solve word problems?

Results from ANCOVA indicated that when the experiment group was administered personalized instructional materials and test, there was a significant difference in learner motivation between the experimental and control groups, after controlling for Week 1 learner motivation scores. Profile analysis was conducted for further assessment of Research Question 2. One profile analysis for learner motivation and group type of conducted for additional analysis for both Research Question 2 and 3. Results of the multivariate test indicated that no significant differences existed between group profiles across the three IMMS scores. Results from the between-subjects analysis indicated that no significant difference existed in the average of three motivation scores between groups.

Research Question 3 (RQ3): What is the effect of individual personalization on long term learner motivation?

Results from the ANCOVA indicated that there was no significant difference in learner motivation in Week 3 of the experimental and control groups after controlling for learner motivation measured in Week 1. The significant difference of learner motivation found in Week 2, when the experimental group was administered personalized instructional materials, was not sustained in Week 3, when the experimental group was again administered the non-personalized instructional materials. Thus, the null hypothesis for Research Question 3 was retained.

Conclusions and Implications

Academic achievement. Cognitive information processing involves memory systems that receive information and then transform the information for storage and use for both memory and performance. Driscoll (2005) hypothesized that the processes of attention, encoding, and retrieval of information that is received, transformed, and stored have an effect on the information as it is received, transformed, and stored. The attention process directs the learner's attention to specific material to be learned while the encoding process facilitates the learner in making personally meaningful associations between existing knowledge and new knowledge. The retrieval process enhances the learner's ability to recall information from memory storage to specific contexts. By incorporating instructional designs that strengthen the process of attention, encoding, and retrieval, cognitive information processing can be augmented.

Integrating learner background information into instruction has been shown to enhance meaningfulness to the learner (Ross, 1983). There were many studies reviewed in the literature review that indicate that personalization is effective in improving problem-solving skills for learners (Akinsola & Awofala, 2009; Anand & Ross, 1987;

Hart, 1996; Harter & Ku, 2007; Ku & Sullivan, 2002; Lopez & Sullivan, 1991, 1992). Morrison, Ross, and Baldwin (1992) also indicated that adapting instruction to learners' needs positively affects cognition and motivation. Miller and Kulhavy (1991) indicated that personalization increased retrieval of associated material, enhancing the ability of the learners to connect with word problems by placing themselves mentally in the problems. Personalization has been shown to have a stronger effect on mathematics achievement with the use of more complex mathematical word problems, such as two-step problems, as used in this study, than with one-step word problems (Lopez & Sullivan, 1992).

Given the wealth of information providing support for the use of personalization on mathematics achievement, it is somewhat surprising that no significant difference in achievement was found in the present study between an experimental group that received personalized materials and a control group that did not. Perhaps the reason for this inconsistency lies in the math ability of the participants themselves. According to Ku et al. (2007), personalization has a stronger effect on lower-level math knowledge learners than on higher-level learners. Since the results indicate similar high level performance results between experimental and control groups it may have been the case that the learners did not have particularly low-level math knowledge despite being enrolled in a developmental math course.

The mean results from the test taken in Week 2 were not significantly different between the experimental group and control group. Both the experimental and control groups had high average mean value Week 2 test scores. The experimental Week 2 average test percentage was 89.87% and the control average test percentage was 82.0%. When reviewing the group profiles across the three module tests, no significant difference was seen. That is, there was no difference between groups nor was there is a difference between weekly tests. This would indicate that the participants were similar in regards to their seemingly high math ability levels.

The effect of personalized instruction was not shown to have a significant impact on mathematical achievement by college learners. There was no significant difference in Instructional Module 2 test scores between learners administered personalized instructional materials and learners administered non-personalized instructional materials. This indicates that the two groups had similar performance abilities to solve mathematical word problems.

Motivation. The effect of personalized instruction was shown to have a significant effect on learner motivation. Differences in motivation were seen immediately after the administration of the differentiated materials, with the experimental group outperforming the control group. Levels of motivation for both experimental and control groups over the three week time period were shown in Figure

4.2. Although both experimental and control group motivation levels decreased from Week 1 to Week 2, the experimental group experienced less of a drop in motivation than the control group, resulting in a higher motivation level for the experimental group. While the motivation levels for the experimental group did not increase after the administration of personalized materials, personalization appeared to have the effect of lessening or decreasing the rate of demotivation when compared to the control group motivation results.

According to Keller (2010), motivation "refers broadly to what people desire, what they choose to do and what they commit to do" (p. 3). Learner motivation is comprised of two types of motivation: intrinsic and extrinsic. The learner can have various level of both intrinsic and extrinsic motivation at the same time. Motivation to perform tasks for the enjoyment or challenge of the task is considered intrinsic while performing tasks for rewards linked to successful performance is considered extrinsic.

Learner motivation can be enhanced by connecting to students' interests in order to increase perceived relevance of mathematics (Ma, 1997). Personalization was used as a strategy in this study by imbedding students' personal information and interests into mathematical instructional units. By personalizing Week 2 module instruction, the resulting motivation among the experimental group was significantly greater than among the control group. It appears that individual personal preferences imbedded into the instructional units for the experimental group created a connection to the learners' interests and perceived relevance of mathematics.

Findings from the literature review support the effect of personalization on attitudes, interest, and motivation. Anand and Ross (1987) stated that greater learner attitudes resulted with personalized treatment. Lopez and Sullivan (1992) indicated that individual personalization had greater effects on attitude than group personalization. Learners in the individual personalization group stated that the instruction had more familiar information such as persons, things, and places. Based on this, the learners expressed interest to solve more individually personalized mathematical word problems in the future (Lopez & Sullivan, 1992). This may explain the positive effect on learner motivation found in the present experimental group.

Ku et al. (2007) also reported positive attitudes by learners receiving individual personalization. Learners expressed that the personalization of instruction was easy and likeable and would want to do more math problems that reflected personalization. Learners who are motivated exhibit greater effort and persistence (Wolters & Rosenthal, 2000). In light of this statement, perhaps personalizing instructional units more frequently throughout a course semester would result in greater cumulative motivation, which in turn may show achievement increases towards the end of the course. It is recommended that the study be repeated using personalization throughout the course semester to determine if motivation is cumulative to personalization treatment.

Non-cognitive influences such as motivation, anxiety, and poor instruction are elements that, according to Koller et al. (2001), result in lower math achievement. By consistently and continually applying personalization to increase motivation levels, perhaps greater math achievement can be realized. Perhaps the effects of personalization on achievement may be seen after long-term implementation of personalization, despite the hypothesis of Ross et al. (1988) that personalization may become ineffective if it is consistently applied to each instructional unit throughout a course semester. This warrants further investigation, as intuitively it seems increased motivation would lead to increased achievement. Additionally, perhaps there is a delay in increasing math achievement levels until enough exposure to administration creates a cumulative effect. In other words, repeated personalization may positively affect long term motivation levels, contrary to Ross et. al's hypothesis.

It is both difficult to establish personal contact with each student, as well as have each learner trust that the instructor has addressed their individual needs, interests, and goals (Kim & Keller, 2008). Personalization of instruction with specific and relevant learner interests may increase the attention of the learner to the material. As well, the personalized information reflects favorite items or persons, which theoretically enhances relevance to the learner.

Past studies indicated that learners prefer personalized instruction (Ku & Sullivan, 2000; Lopez & Sullivan, 1992). Learners put forth greater effort to solve problems when word problems reflect personal interests (Mayer, 1998). Learners can better relate the information in the word problem to real life situations, which may in turn motivate them to enhance persistence and effort. Personalization may enhance learners' familiarity with instructional content and they may perceive the problem with less difficulty by a reduction in cognitive load (Lopez & Sullivan, 1991, 1992; Miller & Kulhavy, 1991).

Long term motivation. The effect of personalized instruction was not shown to have a significant effect on long term learner motivation. There was no significant difference between motivation levels in Week 3 between the experimental and control groups. The effect of lessening demotivation did not continue into Week 3 for the experimental group. This suggests that personalization helps motivation in the short term, directly after it has been applied, but the effect is not lasting once personalization ceases. It appears that the effect of personalization, if not continued, does not affect long term learner motivation.

Limitations

The number of participants providing data was lower than anticipated. This may have affected the outcome and conclusions drawn. Future studies with larger sample sizes would be beneficial since a larger sample size would increase statistical power, which may reveal achievement differences (Tabachnick & Fidell, 2007).

Since both the Module 2 instruction and test were personalized for the experimental group in Week 2, it is difficult to determine if the non-significant differences found in this study were a result of the personalized instruction, the personalized test, or perhaps both. Future researchers should seek to address this limitation when conducting similar studies. The results also may have been limited by the fact that some participants may have taken previous math courses and potentially already received similar instruction for the same topics covered within the present study's coursework. This limitation may have affected the achievement and motivational dependent variables.

The Hawthorne effect may also have limited the results obtained in this study. It is possible that participants may have performed better than expected because they were knowingly participating in this research study. If this were the case, it may have resulted in smaller differences between the treatment and control group.

Recommendations for Further Study

There are several recommendations for future studies regarding the instructional strategy of personalization at the college level on achievement and motivation. Several recommendations logically follow on from the results of the present study. Firstly, it is recommended that similar studies be conducted with larger sample sizes in order to ensure sufficient statistical power for identifying potential differences between groups.

It is recommended that the effects of personalization of instruction be explored separately from the personalization of tests in order to determine which, if any, have an effect on learners' mathematical acquisition. For example, to determine if personalized instruction affected learner achievement, the control group would receive standard instruction and the experimental group would receive personalized instruction, but both groups would receive standardized tests. Likewise, to determine if personalization of tests has an effect on learner acquisition, then both control and experimental groups would receive standardized instruction but only the experimental would receive personalized tests.

Another variation on the present study would be to have two experimental groups. One experimental group would receive standardized instruction and personalized testing, while the other would receive personalized instruction and standardized testing. Results from these groups could be compared against results from a control group, which would receive standardized instruction and standardized testing. The motivation surveys could be administered after each test in each of the situations described above to determine if there is cumulative effect on motivation by personalization or not.

It must be kept in mind that Ross et al. (1988) hypothesized personalization would become ineffective if consistently applied to each instructional unit throughout a course semester. However, this hypothesis cannot be applied in this circumstance since there was only a single treatment of personalization administered. It is therefore recommended that future researchers take this into account by including an additional experimental group in which personalization is administered throughout the course of a semester versus sporadically or only once.

Recommendations for Practice

There are several recommendations for practice for various stakeholders in the application of personalization to instructional materials. In order for instruction to be personalized, individual data from students must be gathered using an instrument such as a favorites list, as used in this study, and embedded in instructional modules.

Initially, personalization of instructional materials is very time consuming for the instructor, as it requires entering all the information into a data base. However, once all the information has been entered into a data base and merged with the instructional modules, the time spent simply involves proof-reading the material to ensure that all items from the favorites list embedded into the instructional material are logical. Therefore it is recommended that the favorites list include items that can be interchanged in case a favorite item is left blank. Having a larger data base of favorite things and using them throughout a longer period of time, such as an entire semester, may reduce the possibility of boring the learners with the same items. Seeing the same favorites may fatigue the students and make them less sensitive towards seeing their personalized items. Educational leaders, such as administrators, could provide support to instructors in terms of time allotted and assistance to develop personalized instructional materials. For example, educational leaders could encourage instructors' use of personalization for those learners that are struggling with word problems in areas of not only math but perhaps other areas as well, such as English, history, and the sciences.

Educational software companies and textbook publishers are encouraged to develop and provide software that would support instructors in the task of personalization. The creation of user- friendly software may allow greater time efficiency for instructors, learners, and parents. For example, the software may prompt learners to identify many favorite items, such as favorite foods, friends' names, and favorite activities, such as shopping or sports. The instructional units should be designed so that the favorite items could easily be merged into instruction, thereby creating user-friendly, interesting, and relevant instruction efficiently. With a greater database of favorites, each instructional unit could reflect favorites without a high level of repetition that may cause learner boredom.

For instructors considering using personalization, it is recommended that individual personalization be used rather than group personalization. Group personalization represents the most common response to the favorites list, such as favorite entertainer or favorite food. Although there are several studies that have used group personalization for younger learners with success, it would be difficult to use group personalization for college learners due to the diversity of personal preferences. In other words, there may not be a common favorite item but instead unique favorite items. However, it would be well worth considering using personal leisure activity themes for preferences, such as shopping or specific sports.

Based on the results of this study that personalization decreases motivation, it is recommended that instructional design incorporate personalized information in all math word problem solving instructional units and tests. It has been shown that motivation increased with personalization but was not sustained in the ensuing week. Therefore, in order to maintain gains made in motivational levels, it is recommended that personalization be incorporated as an instructional strategy throughout not only math curriculum, but other subject matters as well. Instructors can identify learner interests early in the semester and then use these to personalize all lessons throughout the semester.

Summary

Increasing demands for an educated work force necessary to compete in the global economy call for greater numbers of college graduates. Concerns regarding graduation trends have been raised by global and national politicians and educational experts alike. Graduate requirements including demonstrating mathematical proficiency such as solving mathematical word problems are considered a challenge by many college undergraduates. Such undergraduates requiring improvement in mathematical proficiency enroll in developmental math courses. Therefore, increasing the success rate of undergraduates in developmental math courses can lead to improved college graduation rates. Effective instructional strategies such as personalization of instruction have shown positive results in both mathematical achievement and attitude for learners in upper elementary grades and high school.

In this study, undergraduates in a developmental math class participated in a three week study period using authentic course module units and tests. The experimental group were administered non-personalized instruction and tests during Weeks 1 and 3 and personalized instruction and tests during Week 2. The control group received non-personalized instruction for Weeks 1, 2, and 3. Motivational surveys were administered after each test. Mathematical test results were compared between the two groups to determine if personalization had an effect on mathematical acquisition. Additionally, motivation survey results were compared between the two groups to determine if personalization had an effect on motivation.

Results indicated that personalization did not have an effect on mathematical acquisition. However, motivation levels were greater for the experimental group administered personalization in Week 2 than the control group administered non-personalized instruction. Motivation gains from Week 2 were not maintained into Week 3 by the experimental group. However, it did appear that the experimental group experienced a lesser decrease in motivation than the control group.

The effect of personalization on motivation was shown to be effective for those learners administered personalized instruction and testing. Providing word problems with specific personal interests increased the attention of the learner and the relevance to the instructional material. The ability to better relate to word problems to real life situations may enhance learner persistence and effort and thereby increase motivation levels. Motivation levels were not maintained when the administration of personalization stopped. That is, motivation levels did not increase nor maintained once the administration of personalization ceased. If personalization is not continued, long term motivation gains are not realized.

It is recommended that personalization be applied to mathematical word problems for learners at the college level. By establishing a large data base of favorite items, which are relevant and interesting to learners, instructional units and tests can be personalized and used throughout developmental math courses. Personalization of instructional units would have a positive influence on the achievement of college undergraduates.

APPENDIX A: RESEARCH INFORMATION SHEET

Title of Study: The Effect of Individual Personalization on Solving Mathematical Word Problems

Principal Investigator (PI):Danica Vukmirovic, College of Education, Wayne State University (705) 728-1968 x1041

Purpose: You are being asked to participate in a research study that is looking at the effects of personalized instruction on math achievement at Georgian College because you are enrolled in a math course that addresses solving word problems. This study is being conducted at Georgian College by Danica Vukmirovic as part of her doctoral studies at Wayne State University.

Study Procedures: If you take part in the study, outside of the normal activities in the class, you will be asked to complete a Favorites List form and three motivational surveys about instruction materials. The activities are as follows:

- A Favorites List that asks you to identify your personal preference such as your favorite fruit and grocery store as well as other items (approximately 10 minutes)
- Instruction which is already part of your course work
- Post-instructional math test which is already part of your course work
- Complete three motivation surveys about the instructional materials (10 minutes each)

Benefits: As a participant in this research study, there will be no direct benefit for you; however, information from this study may benefit other people in the future.

Risks: There are no known risks at this time to participation in this study.

Costs: There will be no costs to you for participation in this research study.

Compensation: For taking part in this research study, you will be given four $5 Tim Horton gift cards. You will receive the first card when you return your completed Favorites List and the other three after you return your completed motivation surveys.

Confidentiality: You will be identified in the research records by a code only.

Voluntary Participation / Withdrawal: Taking part in this study is voluntary. You may choose not to take part in this study, or if you decide to take part, you can change your mind later and withdraw from the study. You are free to not answer any questions or withdraw at any time. Your decision will not change any present or future relationships with Georgian College or Wayne State University or its affiliates.

Questions: If you have any questions about this study now or in the future, you may contact Danica Vukmirovic at the following phone number (705) 728-1968 x1041. If you have questions or concerns about your rights as a research participant, the person to contact at Georgian College is Richard Acton-Rinaldo, Chair, Georgian College Research Ethics Board at (705) 728-1968 or rrinaldo@georgianc.on.ca.

As well the Chair of the Human Investigation Committee can be contacted at (313) 577-1628. If you are unable to contact the research staff, or if you want to talk to someone other than the research staff, you may also call (313) 577-1628 to ask questions or voice concerns or complaints.

Participation: By completing and submitting the Favorites List you are agreeing to participate in this study.

APPENDIX B: FAVORITES LIST

FAVORITES LIST

Participant's first name only: _______________ Alphanumeric Number: ____________

Gender: ◎Male
◎Female

Age (years): ___________

I want to know some things about you!
Please print your most favorite in the column with the title "Your Favorite"

		Your Favorite (Please list one response only)
1	**Female Singer**	
2	**Magazine**	
3	**Soft drink**	
4	**Chocolate bar**	
5	**Restaurant**	
6	**Fruit**	
7	**Movie star**	
8	**Sport**	
9	**Grocery store**	
10	**Car**	
11	**Beach**	
12	**Flower**	
13	**Bird**	
14	**Gem**	
15	**Aquarium fish**	
16	**Planet**	
17	**What are the names of your TWO closest female friends?**	**1.** ___________________________ **2.** ___________________________

18	**What are the names of your TWO closest male friends?**	**1.** ___________________________ **2.** ____________________________

APPENDIX C: EXAMPLE INSTRUCTION FOR CONTROL AND TREATMENT 1

Control Group Instruction Example

A magazine has a two page article. The two pages add up to 81. What are the page numbers?

Treatment 1 Individual Instruction Example

The magazine Rolling Stone (favorite magazine) has a two page article. The two pages add up to 81. What are the page numbers?

The number on the left page is ___ and the number on the right page is _____.

APPENDIX D: TEST EXAMPLES FOR CONTROL AND TREATMENT 1

Control Group Instruction Example

Control Test Example

Joe was 13 years older than Mary. Together their ages totaled 80 years. What were their ages?

Treatment 1 Test Example

Jennifer Anniston (favorite female actor) is 13 years older than her assistant. Together their ages totaled 80 years. What were their ages?

APPENDIX E: MOTIVATION SURVEY

Instructional Materials Motivation Survey (IMMS)

Alphanumeric Number: _________

Math Module Number: __________

Hello,

There are 36 statements in this questionnaire. Please think about each statement in relation to the instructional materials you have just studied and indicated how true it is. Give the answer that applies to you, and not what you would like to be true, or what you think others want to hear.

Think about each statement by itself and indicate how true it is. Do not be influenced by your answers to other statements.

Record your responses on the answer sheet that is provided and follow any additional instructions that may be provided in regard to the answer sheet that is being used with this survey. Thank you.

Use the following values to indicate your responses to each item.

1 = Not true
2 = Slightly true
3 = Moderately true
4 = Mostly true
5 = Very true

THANK YOU FOR PARTICIPATING

For research and development studies, Keller's Instructional Material Motivation Survey is available with permission.

Instructional Materials Motivation Survey

John M. Keller
Florida State University
jkeller@fsu.edu

	Circle your choice				
	Not True	Slightly True	Moderately True	Mostly True	Very True
1. When I first looked at this lesson, I had the impression that it would be easy for me.	1	2	3	4	5
2. There was something interesting at the beginning of this lesson that got my attention.	1	2	3	4	5
3. This material was more difficult to understand than I would like for it to be.	1	2	3	4	5
4. After reading the introductory information, I felt confident that I knew what I was supposed to learn from this lesson.	1	2	3	4	5
5. Completing the exercises in this lesson gave me a satisfying feeling of accomplishment	1	2	3	4	5
6. It is clear to me how the content of this material is related to things I already know	1	2	3	4	5
7. Many of the pages had so much information that it was hard to pick out and remember the important points.	1	2	3	4	5
8. These materials are eye-catching.	1	2	3	4	5
9. There were stories, pictures, or examples that showed me how this material could be important to some people.	1	2	3	4	5

10. Completing this lesson successfully was important to me.	1	2	3	4	5
11. The quality of the writing helped to hold my attention.	1	2	3	4	5
12. The lesson is so abstract that it was hard to keep my attention on it.	1	2	3	4	5
13. As I worked on this lesson, I was confident that I could learn the content.	1	2	3	4	5
14. I enjoyed this lesson so much that I would like to know more about this topic.	1	2	3	4	5
15. The pages of this lesson look dry and unappealing.	1	2	3	4	5
16. The content of this material is relevant to my interests.	1	2	3	4	5
17. The way the information is arranged on the pages helped keep my attention.	1	2	3	4	5
18. There are explanations or examples of how people use the knowledge in this lesson.	1	2	3	4	5
19. The exercises in this lesson were too difficult.	1	2	3	4	5
20. This lesson has things that stimulated my curiosity.	1	2	3	4	5
21. I really enjoyed studying this lesson.	1	2	3	4	5
22. The amount of repetition in this lesson caused me to get bored sometimes.	1	2	3	4	5
23. The content and style of writing in this lesson convey the impression that its content is worth knowing.	1	2	3	4	5

24. I learned some things that were surprising or unexpected.	1	2	3	4	5
25. After working on this lesson for a while, I was confident that I would be able to pass a test on it.	1	2	3	4	5
26. This lesson was not relevant to my needs because I already knew most of it.	1	2	3	4	5
27. The wording of feedback after the exercises, or of other comments in this lesson, helped me feel rewarded for my effort.	1	2	3	4	5
28. The variety of reading passages, exercises, illustrations, etc., helped keep my attention on the lesson.	1	2	3	4	5
29. The style of writing is boring.	1	2	3	4	5
30. I could relate the content of this lesson to things I have seen, done, or thought about in my own life	1	2	3	4	5
31. There are so many words on each page that it is irritating.	1	2	3	4	5
32. It felt good to successfully complete this lesson.	1	2	3	4	5
33. The content of this lesson will be useful to me.	1	2	3	4	5
34. I could not really understand quite a bit of the material in this lesson.	1	2	3	4	5
35. The good organization of the content helped me be confident that I would learn this material.	1	2	3	4	5

36. It was a pleasure to work on such a well-designed lesson.	1	2	3	4	5

APPENDIX F: MOTIVATION SURVEY SCORING GUIDE

IMMS Scoring Guide

Attention	Relevance	Confidence	Satisfaction
2	6	1	5
8	9	3(reverse)	14
11	10	4	21
12 (reverse)	16	7(reverse)	27
15(reverse)	18	13	32
17	23	19(reverse)	36
20	26(reverse)	25	
22(reverse)	30	34(reverse)	
24	33	35	
28			
29(reverse)			
31(reverse)			
12 questions	**9**	**9**	**6**

APPENDIX G: PERMISSION TO USE IMMS INSTRUMENT

RE: Permission to use IMMS survey
May 22, 2012 2:45 PM

To:"John Keller"
<jkeller@fsu.edu>

From:"Danica Vukmirovic" <aj1956@wayne.edu

Dear Danica,
You are welcome to use the IMMS without charge. Do you have a copy of it and the scoring information?
Sincerely,
John K.

John M. Keller, Ph.D.
Professor Emeritus
Educational Psychology and Learning Systems
Florida State University
9705 Waters Meet Drive
Tallahassee, FL 32312-3746
Phone: 850-294-3908

Official ARCS Model Website: http://arcsmodel.com
Professional Website: http://mailer.fsu.edu/~jkeller/JohnsHome/

Keller, J.M. (2010), Motivational Design for Learning and Performance: The ARCS Model Approach. New York: Springer. Now available in English and Japanese. Will soon be available in Korean.

"Do not seek to follow in the footsteps
of the men of old. Seek what they sought."

Bashō (1644 – 1694)

APPENDIX F: NOTICE OF EXPEDITED AMENDMENT APPROVAL

WAYNE STATE UNIVERSITY

IRB Administration Office
87 East Canfield, Second Floor
Detroit, Michigan 48201
Phone: (313) 577-1628
FAX: (313) 993-7122
http://irb.wayne.edu

NOTICE OF EXPEDITED APPROVAL

FILE

To: Danica Vukmirovic
Administration & Organization Stud

From: Dr. Scott Millis
Chairperson, Behavioral Institutional Review Board (B3)

Date: September 18, 2012

RE: IRB #: 087512B3E

Protocol Title: Effect of Individual Personalization on Solving Mathematical Word Problems

Funding Source:

Protocol #: 1208011228

Expiration Date: September 17, 2013

Risk Level / Category: Research not involving greater than minimal risk

---

The above-referenced protocol and items listed below (if applicable) were **APPROVED** following *Expedited Review* Category (#7)* by the Chairperson/designee *for* the Wayne State University Institutional Review Board (B3) for the period of 09/18/2012 through 09/17/2013. This approval does not replace any departmental or other approvals that may be required.

- Protocol Summary Form (received in the IRB Office 9/12/12)
- Protocol (received in the IRB Office 8/16/12)
- Receipt of Export Control review indicating that no export control issues exist (dated 7/24/12)
- The request for a waiver of the requirement for written documentation of informed consent has been granted according to 45 CFR 46.117(1)(2). Justification for this request has been provided by the PI in the Protocol Summary Form. The waiver satisfies the following criteria: (i) The only record linking the participant and the research would be the consent document, (ii) the principal risk would be potential harm resulting from a breach of confidentiality, (iii) each participant will be asked whether he or she wants documentation linking the participant with the research, and the participant's wishes will govern, (iv) the consent process is appropriate, (v) when used requested by the participants consent documentation will be appropriate, (vi) the research is not subject to FDA regulations, and (vii) an information sheet disclosing the required and appropriate additional elements of consent disclosure will be provided to participants not requesting documentation of consent.
- Research Information Sheet (dated 9/7/12)
- Data collection tools: Example Instructions for Control Group and Experimental Group, Test Examples for Control and Experimental Groups, Favorites List, and Instructional Materials Motivation Survey (IMMS)

- Federal regulations require that all research be reviewed at least annually. You *may* receive a *"Continuation Renewal Reminder"* approximately two months prior to the expiration date; however, it is the Principal Investigator's responsibility to obtain review and continued approval ***before*** the expiration date. Data collected during a period of lapsed approval is unapproved research and can never be reported or published as research data.
- All changes or amendments to the above-referenced protocol require review and approval by the IRB **BEFORE** implementation.
- Adverse Reactions/Unexpected Events (AR/UE) must be submitted on the appropriate form within the timeframe specified in the IRB Administration Office Policy (http://www.irb.wayne.edu//policies-human-research.php).

NOTE:

1. Upon notification of an impending regulatory site visit, hold notification, and/or external audit the IRB Administration Office must be contacted immediately.
2. Forms should be downloaded from the IRB website at **each** use.

REFERENCES

Akinsola, M. K. & Awofala, A. O. A. (2009). Effect of personalization of instruction on students' achievement and self-efficacy in mathematics word problems. *International Journal of Mathematical Education in Science and Technology*, *40*(3), 389-404.

Alexander, P. A. & Murphy, P. K. (1998). Profiling the differences in students' knowledge, interest, and strategic processing. *Journal of Educational Psychology*, *90*, 435-47.

Anand, P. D., & Ross, S. M. (1987). Using computer-assisted instruction to personalize arithmetic materials for elementary school students. *Journal of Educational Psychology*, *79*(1), 72-28.

Atkinson, R. C. & Shiffrin, R. M. (1968). Human memory: a proposed system and its control processes. In *The Psychology of Learning and Motivation: Advances in Research and Theory*, Vol. 2, edited by K. W. Spence and J. T. Spence, pp.89–195. New York: Academic Press.

Aud, S., Hussar, W., Kena, G., Bianco, K., Frohlich, L., Kemp, J., Tahan, K., & Mallory, K. (2011). *The condition of education* (NCES Report No. 2011-033). Retrieved from http://www.bls.gov/news.release/archives/ecopro_12102009.pdf

Autor, D. H., Levy, F., & Murnane, R. M. (2003). The skill content of recent technological change: An empirical exploration. *The Quarterly Journal of Economics, 114(*4), 1279-1333.

Bahr, P.R. (2008). Does mathematics remediation work? A comparative analysis of academic attainment among community college students. *Research in Higher Education, 49*(5), 420-450.

Bailey, T. (2002). Taking the problems out of word problems. *Teaching Pre K-8, 32*(4), 60-61.

Bandalos, D. L., Yates, K., & Thorndike-Christ, T. (1995). Effects of math self-concept, perceived self-efficacy, and attributions for failure and success on test anxiety. *Journal of Educational Psychology, 87*(4), 611-623.

Bandura. A. (1977). *The exercise of control.* W.H. Freeman & Company, New York

Bandura, A. (1997). *Self-Efficacy: The exercise of control.* New York: W.H. Freeman.

Bates, E. T. & Wiest, L. R. (2004). Impact of personalization of mathematical word problems on student performance. *The Mathematics Educator*, *14*(2), 17-26.

Bong, M. (2004). Academic motivation in self-efficacy, task value, achievement goal orientations, and attributional beliefs. *The Journal of Educational Research 97*(6): 287-297.

Bourquin, S.D. (1999). *The relationship among math anxiety, math self-efficacy, gender, and math achievement among college students at an open admissions commuter institution* (Doctoral dissertation). Retrieved from ProQuest Dissertations and Theses database. (AAT 9923662)

Boylan, H. R. (2002). *What works: Research-based best practices in developmental education.* Boone, NC: National Center for Developmental Education.

Brophy, J. (1986). Teaching and learning mathematics: Where research should be going. Journal for Research in Mathematics Education, 17 (5), 323-346.

Butler, R. & Nissan, M. (1986). Effects of no feedback, task-related comments, and grades on intrinsic motivation and performance. *Journal of Educational Psychology, 78*, 21-24.

Cakir, O., Simsek, N., & Tezcan, N. (2009). A web based generation system for personalization of e-learning materials. *International Journal of Social Sciences, 4*(4), 283-286.

Campbell, D.T., & Stanley, J.C. (1963). *Experimental and quasi experimental design for research.* Chicago, IL: Rand McNally College Publishing Company.

Cassady, J. C. & Johnson, R. E. (2002). Cognitive test anxiety and academic performance. *Contemporary Educational Psychology, 27*, 270-95.

Cawelti, G., Grouws, D. A., & Cebulla, K. J. (1999). *Improving student achievement in mathematics: Based on the handbook of research on improving student achievement.* Arlington, VA: Educational Research Service.

Chapell, M. S., Blanding, Z. B., Silverstein, M. E., Takahashi, Newman, B., Gubi, A., & McCann, N. (2005). Test anxiety and academic performance in undergraduate and graduate students. *Journal of Educational Psychology, 97(2)*, 268-274.

Creswell, R. (2012). *Educational research: Planning, conducting, and evaluating quantitative and qualitative research (4th ed.)*. Upper Saddle River, NJ: Pearson Prentice Hall.

Davis-Dorsey, J., Ross, S. M., & Morrison, G. R. (1991). The role of rewording and personalization in the solving of mathematical word problems. *Journal of Educational Psychology*, *83*(1), 61-68.

De Corte, E., Verschaffel, L., & De Win, L. (1985). Influence of rewording verbal problems on children's problem representations and solutions. *Journal of Educational Psychology*, *77*(4), 460-470.

Deci, E. L. (1996). Making room for self-regulation: Some thoughts on the link between emotion and behavior. *Psychological Inquiry, 7*, 220-223.

Deci, E. L., Koestner, R., & Ryan, R. M. (1999). A meta-analytic review of experiments examining the effects of extrinsic rewards on intrinsic motivation. *Psychological Bulletin, 125*, 627-68.

Deci, E. L., Vallerand, R. J., Pelletier, L. G., & Ryan, R. M. (1991). Motivation and education: The self-determining perspective. *Educational Psychologist, 26*, 325-346.

Deitte, J. M. &Howe, M. R. (2003). Motivating students to study mathematics. *The Mathematics Teacher, 96*(4), 278-280.

Driscoll, M. P. (2005). *Psychology of learning for instruction* (3rd ed.). Needham Heights, MA: Allyn & Bacon.

Elliot, J. & Knight, J. A. (2005). Student motivation: The bottom line. *The Agricultural Educational Magazine, 4*, 8-10.

Ensign, J. (1997). *Linking life experiences to classroom math.* Paper presented at the annual meeting of the American Educational Research Association, Chicago IL, ERIC ED 412093.

Frymier, A. (1994). A model of immediacy in the classroom. *Communication Quarterly, 42*, 133-144.

Glynn, S. M., Aultman, L. P., & Owens, A. M. (2005). Motivation to learn in general education programs. *The Journal of General Education, 54*(2), 150-170.Gollwitzer., P.M. (1993). Goal achievement: The role of intentions. *European Review of Social Psychology, 4,* 141-185.

Gottfried, A. E. (1985). Academic intrinsic motivation in elementary and junior high school students. *Journal of Educational Psychology, (77),* 6, 631-645.

Graham, S., & Weiner, B. (1996). Theories and principles of motivation. In D. Berliner & R. Calfee (Eds.), *Handbook of educational psychology* (pp. 63-84). New York: Macmillan

Greeno, J. G., Collins, A. M., & Resnik, L. B. (1996). Cognition and learning. In D. Berliner & R. Clafee (Eds.), *Handbook of educational psychology* (pp. 15-46). New York: Macmillan.

Hart, J. M. (1996). The effect of personalized word problems. *Teaching Children Mathematics, 2*(8), 504-505.

Harter, C. A. & Ku, H.-Y. (2007). The effects of spatial contiguity within computer-based instruction of group personalized two-step mathematics word problems. *Computers in Human Behavior, 24(*4), 1668-1685.

Hegerty, M., Mayer, R. E. & Monk, C .A. (1995). Comprehension of arithmetic word problems: A comparison of successful and unsuccessful problem solvers. *Journal of Education Psychology, 87*(1), 18-32.

Herndon, J. N. (1987). Learner interests, achievement, and continuing motivation in instruction. *Journal of Instructional Development, 10*(3), 11-14.

Ironsmith, M., Marva, J., Harju, B., & Eppler, M. (2003). Motivation and performance in college students enrolled in self-paced versus lecture-format remedial mathematics courses. *Journal of Instructional Psychology, 30*(4), 276 -279.

Johnson, M. L. (2006). *Why study mathematics? A test of self-determination theory* (Doctoral dissertation). Retrieved from ProQuest Dissertations and Theses database.(AAT 3210409)

Jonassen, D. H. (1997). Instructional design models for well-structured and ill-structured problem-solving learning outcomes. *Educational Technology Research and Development*, *45*(1), 65-94.

Jonassen, D. H. (2000). Toward a design theory of problem solving. *Educational Technology Research and Development*, *48*(4), 63-85.

Jonassen, D. H. (2002). Engaging and supporting problem solving in online learning. *Quarterly Review of Distance Education, 3*(1), 1-13.

Jonassen, D. H. (2003). Designing research-based instruction for story problems. Educational Psychology Review, 15(3), 267-296.

Jonassen, D. H. (2010). *Research issues in problem solving*. Paper presented at the Eleventh International Conference on Education Research New Educational Paradigm for Learning and Instruction, Seoul, Korea. Abstract retrieved from http://www.aect.org/publications/whitepapers/2010/JonassenICER.pdf

Jonassen, D. H. & Kim, B. (2010). Arguing to learn and learning to argue: Design justifications and guidelines. *Education Technology Research and Development, 58*, 439-457.

Jonassen, D. H., & Kwon, H. I. (2001). Communication patterns in computer mediated versus face-to-face group problem solving. *Education Technology Research and Development, 49*(1), 35-51.

Keller, J. M. (1987a). Development and use of the ARCS model of motivational design. *Journal of Instructional Development, 10*(3), 2-10.

Keller, J. M. (2010). *Motivational design for learning and performance: The ARCS model approach.* New York: Springer.

Kerckhoff, A. C., Raundenbush, S. W., & Glennie, E. (2001). Education, cognitive skill, and labor force outcomes. *Sociology of Education, 74*, 1-24.

Kim, C., & Keller, J. M. (2008). Effects of motivational and volitional email messages (MVEM) with personal messages on undergraduate students' motivation study habits and achievement. *British Journal of Educational Technology, 39*(1), 36-51.

Kintsch, W. (1986). Learning from text. *Cognition and Instruction, 3*(2), 87-108.

Kirsch, I., Braun, H., & Yamamoto,K. (2007). *America's perfect storm*. Retrieved http://www.ets.org/Media/Education_Topics/pdf/AmericasPerfectStorm.pdf

Kirsch, I. S., Jungeblut, A., Jenkins, L., & Kolstad, A. (2002). *Adult literacy in America: A first look at the findings of the national adult literacy survey* (NCES Report No. 1993-275). Retrieved from http://nces.ed.gov/pubs93/93275.pdf

Koller, O., Baumert, J., & Schnabel, K. (2001). Does interest matter? The relationship between academic interest and achievement in mathematics. *Journal for Research in Mathematics Education, 32*(5), 448-470.

Ku, H., Harter, C. A., Liu, P., Thompson, L., & Cheng, Y. (2007). The effects of individually personalized computer-based instructional program on solving mathematics problems. C*omputers in Human Behavior, 23*, 1195-1210.

Ku, H. Y., & Sullivan, H. J. (2000). Personalization of mathematics word problems in Taiwan. *Educational Technology Research and Development, 48*(3), 49-59.

Ku, H. Y., & Sullivan, H. J. (2002). Student performance and attitudes using personalized mathematics instruction. *Educational Technology Research and Development, 50*(1), 21-3.

Kuhl, J. (1984). Volitional aspects of achievement motivation and learned helplessness: Toward a comprehensive theory of action control. In B.A. Maher & W.B. Maher (Eds). *Progress in experimental personality research* (pp. 101-171). Orlando: Academic Press.

Lave, J. & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. Cambridge, MA: Cambridge University Press

Lazarick, L. (1997). Back to the basics: remedial education. *Community College Journal, 68*(2), 11-15.

Lepper, M. R. (1988). Motivational considerations in the study of instruction. *Cognition and Instruction, 5*(4), 289-309.

Levin, H. M., & Belfield, C. R. (2009). *Some Economic Consequences of Improving Mathematics Performance.* Menlo Park, CA: SRI International

Lin, Y. G., McKeachie, W. J., & Kim, Y. C. (2003). College student intrinsic and/or extrinsic motivation and learning. *Learning and Individual Differences, 13*, 251-258.

Lopez, C. L., & Sullivan, H. J. (1991). Effects of personalized math instruction for Hispanic students. *Contemporary Educational Psychology, (16)*, 95-100.

Lopez, C. L., & Sullivan, H. J. (1992). Effect of personalization of instructional context on the achievement and attitudes of Hispanic students. *Educational Technology Research and Development, 40*(4) 5-13.

Ma, X. (1997). Reciprocal relationships between attitude toward mathematics and achievement in mathematics. *The Journal of Educational Research, 90*(4), 221-229.

Malpass, J. R., O'Neil, Jr., H. F., & Hocevar, D. (1999). Self-regulation, goal orientation, self-efficacy, worry, and high-stakes math achievement for mathematically gifted high school students. *Roeper Review, 21*(4), 281-290.

Marshall, S. P. (1995). *Schemas in problem solving*. NY: Cambridge University Press.

Maslow, A. H. (1968). *Toward a psychology of being* (2nd ed.). New York: Van Nostrand.

Mayer, R. E. (1982). Memory for algebra story problems. *Journal of Educational Psychology, 74*, 199-216.

Mayer, R. E. (1998). Cognitive, metacognitive, and motivational aspects of problem solving. *Instructional Science, 26*, 49-63.

Means, T. B., Jonassen, D. H. & Dwyer, F. M. (1997). Embedded relevance: Embedded ARCS strategies vs. purpose. *Educational Technology Research and Development, 45*(1), 5-17.

Meece, J. L., Parsons, J., Kaczal, C. M., Goff, S. B., & Futterman, R. (1982). Sex differences in math achievement: Toward a model of academic choice. *Psychological Bulletin, 91*(2), 324-348.

Middleton, J. A., & Spanias, P. A. (1999). Motivation for achievement in mathematics: Finding, generalizations, and criticisms of the research. *Journal for Research in Mathematics Education, 30*(1), 65-88.

Miller, D. C., & Kulhavy, R. W. (1991). Personalizing sentences and text. *Contemporary Educational Psychology, 16,* 287-292.

Miller, D.C., Sen, A., Malley, L.B. & Burns, S. D. (2009). *Comparative indicators of education in the United States and other G-8 countries: 2009* (NCES Report No. 2009-039). Retrieved from http://nces.ed.gov/pubs2009/2009039.pdf

Miller, G. A. (1956). The magical number seven, plus or minus two: Some limits on our capacity for processing information. *Psychological Review, 63*, 81-97.

Montague, M., Warger, C. & Morgan, T. H. (2000). Solve it! Strategy instruction to improve mathematics problem solving. *Learning Disabilities Research & Practice*, 15(2), 110-116.

Moreno, R., & Mayer, R. E. (2000). Engaging students in active learning: The case for personalized multimedia messages. *Journal of Educational Psychology, 92*(4), 724-733.

Morrison, G. R., Ross, S., & Baldwin, W. (1992). Learner control of context and instructional support in learning elementary school mathematics. *Educational Technology, Research, and Development, 40*(1) 5-13.

Muth, K. D. (1984). Solving arithmetic word problems: Role of reading and computational skills. *Journal of Educational Psychology, 76*(2), 205-210.

Norusis, M. J. (2011). *IBM SPSS Statistics 19 guide to data analysis*. Upper Saddle River, NJ: Pearson.

Nussbaum, E. M., & Sinatra, G., M. (2003). Argument and conceptual engagement. *Contemporary Educational Psychology 28*, 384-395.

Office of the Premier. (2005, May 13). Remarks by Dalton McGuinty, Premier of Ontario to Ryerson University students on postsecondary education. Retrieved from http://news.ontario.ca/opo/en/2005/05/remarks-by-dalton-mcguinty-premier-of-ontario-to-ryerson-university-students-on-postsecondary-educat.html

Organization for Economic Co-operation and Development (OECD). (2010). *Education at a glance.* Paris, OECD.

Organization for Economic Co-operation and Development (OECD) & Statistics Canada. (2005). *Learning a living: First results of the adult literacy and life skills survey*. Paris, OECD.

Organization for Economic Co-operation and Development (OECD). (1996). *The knowledge-based economy*. Paris, OECD.

Orpwood, G., Schollen, Leek, G., Marinelli-Henriques, P., & Assiri, H. (2012). *College Mathematics Project 2011*. Retrieved from http://collegemathproject.senecac.on.ca/cmp/

Pajares, F. (1996). Self-efficacy beliefs and mathematical problem solving of gifted students. *Contemporary Educational Psychology, 21*, 325-344.

Pajares, F. & Graham, L. (1999). Self-efficacy, motivation constructs, and mathematics performance at entering middle school students. *Contemporary Educational Psychology, 24*, 124-139.

Pajares, F. & Miller, D. M. (1995). Mathematics self-efficacy and self-concept beliefs in mathematical problem solving: A path analysis. *Journal of Educational Psychology, 86*(2), 192-203.

Pape, S. J., Bell, C. V. & Yetkin, I. E. (2003). Developing mathematical thinking and self-regulated learning: A teaching experiment in seventh-grade mathematics classroom. *Educational Studies in Mathematics, 53*, 179-202.

Parchman, S. W., Ellis, J. A., Christinaz, D., & Vogel, M. (1997). An evaluation of three computer based instructional strategies in basic electricity and electronics training. Navy Personnel Research and Development Center.

Parker, L. E., & Lepper, M. R. (1992). Effects of fantasy contexts on children's learning and motivation: making learning more fun. *Journal of Personality and Social Psychology, 62*(4) 625-633.

Pintrich, P. R. (2000). Multiple goals, multiple pathways: the role of goal orientation in learning and achievement. *Journal of Educational Psychology, 92*, 544-555.

Pintrich, P. R. & Schunk, D. H. (1996). *Motivation in education: Theory, research, and applications.* Columbus, OH: Merrill.

Proctor, B. E., Floyd, R. G., & Shaver, R. B. (2005). Cattell-Horn-Carroll broad cognitive ability profiles of low math achievers. *Psychology in the Schools, 42*(1), 1-12.

Reeve, J. (1996). *Motivating others: Nurturing inner motivational resources*. Boston: Allyn & Bacon.

Riley, M. S. & Greeno, J. G. (1988). Developmental analysis of understanding language about quantities and solving problems. *Cognition and Instruction*, *5*(1), 49-101.

Ross, S. M. (1983). Increasing meaningfulness of quantitative material by adapting context to student background. *Journal of Educational Psychology*, *75*(4), 519-529.

Ross, S. M., Anand, P. G., & Morrison, G. E. (1988). Personalizing math problems: A modern technology approach to an old idea. *Educational Technology, 26*, 20-25.

Ross, S. M., Anand, P. G., Morrison, G. R., & O'Dell, K. J. (1988). Putting the student into the word problem: Microcomputer-based strategies that personalize math instruction. *Focus on Learning Problems in Mathematics*, *10*(2), 29-42.

Ross, S. M., McCormick, D., & Krisak, N. (1986). Adapting the thematic context of mathematical problems to student interests. *The Journal of Educational Research, 79*, 245-252.

Schubert Walker, L. J., & Stewart, D. W. (2000). Overcoming the powerlessness of procrastination. *Guidance & Counseling*, *16*(1), 39-43.

Schunk, D. H. (1996). Goal and self-evaluative influences during children's cognitive skill learning. *American Educational research Journal, 33*, 359-82.

Schunk, D. H. (2004). *Learning theories: an educational perspective* (4th ed.). New Jersey: Pearson Prentice Hall Education, Inc.

Schunk, D. H., and Zimmerman, B. J. (1997). Social origins of self-regulator competence. *Educational Psychologies, 32*, 195-208.

Shin, N., Jonassen, D.H., & McGee, S. (2003). Predictors of well-structured and ill-structured problem solving in an astronomy simulation. *Journal of Research in Science Teaching, 40*(1), 6-33.

Simons, H. D., Covington, M. V., & Van Rheenen, D. (1999). Academic motivation and the student athlete. *Journal of College Student Development, 40*, 151-62.

Simsek, N. & Cakir, O. (2009). Effect of personalization on students' achievement and gender factor in mathematics education. *International Journal of Social Sciences, 4*(4), 278-282.

Smith, A. E., Jussim, L., & Eccles, J. (1999). Do self-fulfilling prophecies accumulate, dissipate, or remain stable over time? *Journal of Personality and Social Psychology, 77*, 548-65.

Song, S. H., & Keller, J. M. (2001). Effectiveness of motivationally adaptive computer-assisted instruction on the dynamic aspects of motivation. *Educational Technology Research and Development, 49*(2), 5-22.

Sullivan, P., Tobias, S., & McDonough, A. (2006). Perhaps the decision of some students not to engage in learning mathematics in school is deliberate. *Educational Studies in Mathematics*, *62*, (1), 81-99.

Sweller, J. (1999). *Instructional design in technical areas.* Victoria, Australia: ACER Press.

Tabachnick, B. G., & Fidell, L. S. (2007). *Using multivariate statistics* (5th ed). Boston, MA: Pearson.

Tsui, L. (2001). Faculty attitudes and the development of students' critical thinking. *Journal of General Education, 50*, 1-28.

Tuckman, B. W. (2003). The effect of learning and motivation strategies training on college students' achievement. *Journal of College Student Development*, *44*, 430-37.

VanZile-Tamsen, C. & Livingston, J. A. (2001). The differential impact of motivation on the self-regulated strategy use of high- and low- achieving college students. *Journal of College Student Development*, *40*(54-60).

Wade, S. E. (2001). Research on importance and interest: Implications for curriculum development and future research. *Educational Psychology Review, 13*, 243-61.

Walberg, H. J. (1984). Improving the productivity of American schools. *Educational Leadership*, 41, 19-30.

Weiner, B. (1979). A theory of motivation for some classroom experiences. *Journal of Educational Psychology*, *71*(1), 3-25.

Weiner, B. (1990). History of motivational research in education. *Journal of Educational Psychology, 82*, 616-622

Wigfield, A. & Eccles, J. S. (2000). Expectancy-Value theory of achievement motivation. *Contemporary Educational Psychology, 25*, 68-81.

Williams, K. M. (2003). Writing about the problem-solving process to improve problem solving performance. *The Mathematics Teacher, 96*(3), 185 187.

Wolters, C.A., & Rosenthal, H. (2000). The relation between students' motivational beliefs and their use of motivational regulation strategies. *International Journal of Educational Research, 33,* 801-820.

Zimmerman, B. J. (2000). Self-efficacy: an essential motive to learn. *Contemporary Educational Psychology, 25,* 82-91.

Zimmerman, B. J. (1998). Academic studying and the development of personal skill: A self-regulatory perspective. *Educational Psychology, 33*(2/3), 73-86.

ABSTRACT

THE EFFECT OF INDIVIDUAL PERSONALIZATION ON SOLVING MATHEMATICAL WORD PROBLEMS

by

DANICA VUKMIROVIC

December 2013

Advisor: Dr. Monica Welch Tracey

Major: Instructional Technology

Degree: Doctor of Philosophy

Graduation rates are negatively affected by college learners' inability to demonstrate proficiency in mathematics. The purpose of this research study was to determine the effect of individual personalized mathematical instruction on the achievement of solving mathematical word problems by undergraduates enrolled in a college mathematics course. As well, the effect of individual personalized mathematical instruction on undergraduate motivation to solve mathematical word problems was also examined.

The research undertaken was a true experimental post-test only, control group design that took place over three consecutive weeks. Participants were randomly assigned to either the experimental group or the control group. The experimental

group received individual personalized mathematical word problem instructional materials in week 2 only and the non-personalized instructional materials during week 1 and week 3. The control group used non-personalized instructional materials only during this time period. Each group completed a weekly IMMS survey to measure motivation.

Results from the analysis of covariance (ANCOVA) indicated that there was no significant difference of achievement between group types. ANCOVA results indicated that there was a significant difference in motivation between the experimental and control groups during week 2; however, there was no significant difference in learner motivation between group types in week 3. It is recommended that the study be repeated using personalization throughout the course semester to determine if motivation is cumulative to personalization treatment.

AUTOBIOGRAPHICAL STATEMENT

Danica Vukmirovic currently holds a faculty position with Georgian College and has been an active teaching professional since 1990. Danica has developed, designed, and delivered both online and traditional courses at both the diploma and degree levels for programs offered in the engineering, health sciences, and automotive fields. She holds a Bachelor of Science degree from the University of Waterloo and a Master of Science degree from Wayne State University. In 2012, she was awarded the Queen Elizabeth II Diamond Jubilee Medal for her commitment and service to her community, the Canadian automotive aftermarket and her beloved country Canada. She looks forward to continue teaching and researching in the field of education.