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Examination Of An Online College Mathematics Course: Correlation Between Learning Styles And Student Achievement

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EXAMINATION OF AN ONLINE COLLEGE MATHEMATICS COURSE:
CORRELATION BETWEEN LEARNING STYLES AND STUDENT
ACHIEVEMENT

by

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ABSTRACT

The purpose of this study was to determine if there was a significant relationship between learning styles and student learning outcomes in an online college mathematics course. Specifically, the study was guided by two research questions focused on (a) the extent to which learning styles had a predictive relationship with student achievement in an online college mathematics course and (b) the extent to which various learning styles among mathematics students in online versus face-to-face courses predicted mathematics achievement.

The population for this study consisted of the 779 college mathematics and algebra (CMA) students who were enrolled in a private multimedia university located in the southeast. A total of 501 students were enrolled in the online class, i.e., the experimental group, and 278 students enrolled in the face-to-face class comprised the control group. All students completed (a) an initial assessment to control for current mathematics knowledge, (b) the online Grasha-Reichmann Student Learning Styles Scales (GRSLSS) Inventory, and (c) 20 questions selected from the NAEP Question Tool database.

Hierarchical linear regressions were used to address both research questions. A series of ANCOVA tests were run to examine the presence of any relationships between a given demographic and course modality when describing differences between student test scores while controlling for prior academic performance. The results indicated that predominant learning style had no apparent influence on mathematics achievement. The results also indicated that predominant learning style had no apparent influence on

mathematics achievement for online students. When examining demographics alone without respect to modality, there was no significance in course performance between students in various ethnicity, gender, or age groups.

To my family and friends. I would not have made it without each one of you.

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LIST OF ACRONYMS/ABBREVIATIONS

ACCSC	Accrediting Commission of Career Schools and Colleges
CMA	College Mathematics and Algebra
GRSLSS	Grasha-Reichmann Student Learning Styles Scales
NAEP	National Assessment of Educational Progress
NCES	National Center for Educational Statistics

CHAPTER 1
INTRODUCTION

When starting out on online education, in the absence of the knowledge of what
will work and what will not and with no real online pedagogy available, many
teachers will try to merely convert their traditional courses to the Internet.
(Engelbrecht & Harding, 2005a, p. 254)

Background of the Problem

Technological advances have impacted the educational system from which
educators teach to grow tremendously. This has resulted in educators learning and
presenting information using many different methods. Educators might be asked to teach
in traditional face-to-face settings where students and teachers are located in the same
room. They might also teach students via online learning with students located at remote
sites. A third alternative, hybrid instruction, would call upon teachers to combine face-
to-face and online instruction. This third alternative can also be referred to as blended or
mixed mode instruction.

College students have had the flexibility of choosing both the mode and time of
instruction. The flexibility of time and location of online instruction can be very
compelling for students. Accommodating factors may enable some students to take a
class or permit them to choose classes based on personal preference in learning style.
Questions arise as to the conditions that might lead students to a particular choice
between traditional format and an online environment and the extent to which certain
characteristics will contribute to students' success in either environment. It is these
inquiries which guided this research study.

Many studies in different content areas have been conducted on online education. Studies have been focused on management (Daymont & Blau, 2008), nursing (Leners, Wilson, & Sitzman, 2007), accounting (Vamosi, Pierce, & Slotkin, 2004); student participation and interactions (Dennen, 2005; Spector, 2005); student perceptions (Vamosi et al., 2004); student satisfaction (Arbaugh, 2001; Jung, Choi, Lim, & Leem, 2002; Wise, Chang, Duffy, & Del Valle, 2004); and student effectiveness. Unfortunately, there has not been an abundance of research conducted in the area of online mathematics instruction (Engelbrecht & Harding, 2004, 2005b).

There has been limited research conducted on learning styles and online learning (Gordon, 1995). Nevertheless, even in the midst of debating the effectiveness and future promise of online education in postsecondary education, many colleges and universities have adopted online education as part of their long-term strategic plans, (Allen & Seaman, 2007; Xu & Jaggars, 2011). Most of the studies related to online learning and learning styles have compared learning styles to drop-out rates, completion rates, predictors of high risk students, and attitudes about learning (Diaz & Cartnal, 1999). Because research on relationships between online learning and learning styles has been lacking, it is unknown as to whether a particular learning style will provide noteworthy information when designing an online course (Institute for Higher Education Policy, 2000). If a majority of the students' learning styles are similar to those of traditional students, instructors might be able to adapt an online course to provide similar activities to those in face-to-face course activities and teaching pedagogies with similar success rates.

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Instructors should, however, be willing to change their teaching techniques based on students' learning styles. As Sarasin (1998) noted, teachers "should try to ensure that their methods, materials, and resources fit the ways in which their students learn and maximize the learning potential of each student" (p. 10). To design the best instruction for students, teachers should be aware of differences in the learning styles of their online and face-to-face students.

Rationale and Significance of the Problem

"In theory, we operate with the best interest of students in mind. In reality, we plan and make course related decisions based upon our assumptions about what represents the best interest of students" (Grasha, 2002, p. 142).

Compared to a traditional classroom environment, online education is a fairly new delivery mode. It became more and more prevalent during the first decade of the 21st century, and online education enrollments have continued to grow every year (Carlson, 2004). From 1997 to 2007, the United States had an increase of 27% in online enrollment in higher education for a total of 18.2 million students. During the 2006-2007 academic year, 66% of two-year and four-year colleges and universities offered online, hybrid, or other distance education courses. Of these distance education courses, 77% were online courses, 12% were hybrid courses, and 10% were other types of distance education courses (Parsad & Lewis, 2008). In 2008, one in four higher education students took at least one online course (Allen & Seaman, 2010a).

The major reasons higher education programs have been offering online education courses have been to (a) meet students' flexible schedules, (b) reach students who would not be able to drive to campus, (c) provide more courses, and (d) increase student enrollment in spite of the limited space of college facilities (Parsad & Lewis, 2008). These reasons are valid but offer little assurance of representing the best interests in student learning. Additional research conducted on online learning will likely lead to improving online learning pedagogy. It can also lead to better information on the characteristics of students who are more successful in online classes.

Most educators and students are aware that everyone learns differently. One way to examine traits that students possess when learning that has been favorably viewed is the investigation of learning styles (Gordon, 1995). A learning style inventory places students into categories of learning styles which are most favorable for their learning. If certain traits emerge as characterizing students who perform better in online education settings, it would be beneficial to both instructors and students to recognize these learning traits. Exploring this idea in this research was intended to contribute to the existing body of research concerning the consideration of learning styles in regard to modes of instruction.

Examination of the relationship between learning styles and student achievement in online classes adds to the body of literature of mathematics education, online education, and learning styles. It is important for studies to be conducted on learning styles, because students can gain a deeper understanding of the subject if the teaching style and learning style are matched (Giles, Belliveau, DeFreitas, & Casey, 2006).

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Student learning styles can vary depending on the subject matter (Jonassen & Grabowski, 1993). Thus, it is necessary for research to be conducted in various subjects including mathematics (Manochehri & Young, 2006). Given that an increasing number of online classes have been offered in the years immediately preceding this research (Beaudoin, 2002), studying the relationship between learning style and achievement in an online mathematics course was determined to be vital (Ryan, 2001). Researchers have shown that the successful online student needs to be self disciplined and have a lot of initiative (Kearsley, 2002). By investigating the learning styles and mathematics achievement of students in online and face-to-face instructional settings, additional information was gathered and added to the body of research concerning the attributes or characteristics of successful online mathematics students.

This study was conducted to investigate the relationship between achievement and learning styles using the Grasha-Reichmann Student Learning Styles Scales (GRSLSS) in an online mathematics course. Although online instruction has been a topic of interest to researchers, few investigations have focused specifically on the teaching of mathematics online (Engelbrecht & Harding, 2005b). Furthermore, there have been no published studies correlating learning styles and student achievement in an online mathematics course using the Grasha-Reichmann Student Learning Styles Scales (GRSLSS). Because a considerable number of colleges and universities have begun to offer online mathematics courses, it was thought to be imperative that more research take place in this area.

Observing learning styles and achievement of students in online classes was intended to contribute to current practice and scholarship in various ways. If learning styles are recognized as predictors of success in online classes, students may be better able to make informed decisions as to whether they will be more successful in online or face-to-face classes and, if possible, use this information in selecting a mode of instruction. If learning styles of students make a significant difference in learning outcomes, teachers need to be aware of their students' learning styles so they can adequately make adjustments to classroom structures to accommodate students of different learning styles. In contrast, if learning styles do not prove to be significant indicators of achievement, other variables might prevail that are significant for students taking online classes. As Diaz (2000) stated, "Studies that focus on comparing student characteristics, evaluating overall student success, and profiling successful (and non-successful) students might better help us attain that which we all seek: more successful students" (p. 3). Also data have suggested that learning style preference does not impact attainment in mathematics if a student has a high working memory (Alloway, Banner & Smith, 2010).

It seems likely that online classes will continue to flourish; therefore, it is important to provide students with the best possible pedagogy for this environment. Students need to be equipped with tools in order to be successful. If a correlation is found between learning styles and success in online mathematics courses, it would seem appropriate to teach students how to adapt to the "successful" learning style so that they can be sufficiently flexible when they enroll in online courses. Conversely, it might be

possible to adjust online course experiences to meet the needs of learners with counter-indicated learning styles.

Purpose Statement

The examination of learning styles and student achievement in an online mathematics class was intended to not only add to the body of literature, but also to help educators and students. The purpose of this study was to determine if there was a significant relationship between learning styles and student learning outcomes in an online college mathematics course. In addition, the relationship of learning styles to student learning outcomes in the online versus the face-to-face environment was investigated.

Definition of Terms

Mathematics Achievement--An indicator of a student's performance in mathematics based on the results of a formal or informal assessment (Blankstein, 2004).

Baseline--"A basic standard or level; guideline" (Basline, n.d.).

Cognitive Style--The differences of how individuals perceive, problem solve, learn, think, and relate to others. It is the way information is processed in the brain (Witkin & Others, 1977).

Distance Education--The instruction that occurs in real time from one distant site to another using technologies, allowing teachers and students to interact with each other (Halsne, 2002).

Face-to-face instruction--Also referred to as a traditional educational setting. The students and teacher are in the same location or classroom and physically interact with one another during the time of instruction (El Mansour & Mupinga, 2007).

Hybrid instruction--A course having between 30% and 80% of the course content delivered online (Allen & Seaman, 2010a). Hybrid instruction can also be termed as blended or mixed mode instruction.

Learning styles--A collection of "cognitive, affective, and physiological factors that affect how learners perceive, interact with, and respond to the learning environment" (Keefe, 1979, p. 2).

Online instruction/learning--Students receive instruction and course content via the Internet and communication does not occur at the same time (Chute, Hancock, & Thompson, 1999).

Instructional Strategies--Methods used to differentiate a lesson in order to meet the needs of the learning styles of the students (Pollock & Association for Supervision and Curriculum Development, 2007).

<div align="center">Conceptual Perspective</div>

Learning style theory pertains to the body of research concerned with the differences in the ways individuals perceive and process (Husch, 2001). The conceptual framework for this study permitted the investigation of learning styles of college students who were enrolled in mathematics courses taught online and face-to-face and the determination of any differences in academic achievement among students with varying

learning styles. If certain common characteristics were found among successful online mathematics students, the development of these characteristics could be encouraged in students at an early age (Conti & Welborn, 1986; Grasha, 2002). Also researching learning style can provide data on how students learn and help in the design of online courses (Dzakiria, Razak, & Mohamed, 2004).

Because one of the major differences in face-to-face and online instruction is social interaction, the Grasha-Reichmann Student Learning Styles Scales (GRSLSS) was chosen for use in this study. The GRSLSS includes student interaction with the learning process, other students, and the teacher. Reviewing these characteristics was thought to be helpful in determining if there was a correlation in achievement between students who take an online mathematics course and students who take the same course in a traditional face-to-face setting. It was posited that if a correlation was found in this research, the learning style characteristics could be taught to students at a younger age so they would be successful in future online mathematics courses (Conti & Welborn, 1986; Grasha, 2002). Online mathematics course designs could be modified based on knowledge of students' learning styles in individual courses. Similarly appropriate modalities of course enrollment could be advised based on advanced knowledge of students' learning styles.

Research Questions

In this study, student learning styles, as defined by the Grasha-Reichmann Student Learning Styles Scales (GRSLSS), were examined. A determination of correlation was made by comparing students' learning styles and achievement on a mathematics test in an

online mathematics course. This information was used to identify possible indicators of student achievement in an online college mathematics course, controlling for initial differences in performance, in accordance with learning style. Also examined was the relationship between online and face-to-face learning with regard to learning styles and student achievement. Additionally, demographic information from both the online mathematics course and the face-to-face course were examined and compared with a focus on the respective learning styles.

This research study was developed to answer the following questions:

1. Do learning styles have a predictive relationship with student achievement in an online college mathematics course?

    H_{01}: There is no significant relationship among the Grasha-Reichmann Student Learning Styles Scales (GRSLSS) Inventory and student achievement in an online college mathematics course.

2. Do the various learning styles among mathematics students in online versus face-to-face courses predict mathematics achievement?

    H_{02}: There is no significant relationship among various learning styles among mathematics students in online and face-to-face courses and mathematics achievement.

Methodology

The study took place at a private university located in the southeast region of the United States. The population for the research was the students enrolled in online and

face-to-face mathematics classes where the curriculum was the same for both the online and face-to-face courses. Students in face-to-face and online courses were given a learning styles inventory survey and an initial assessment at the beginning of the course. At the conclusion of the course, a mathematics test to gauge student achievement was administered.

The data were analyzed using a full regression model. Data were analyzed using the student initial assessment, differences between students' learning styles as identified by the GRSLSS Inventory, and mathematics achievement as identified using the National Assessment of Educational Progress (NAEP). The data collected from NAEP served as the dependent variable, and individual learning styles and course delivery method were the independent variables.

Delimitations of the Study

The study was delimited to students enrolled in a small, private, non-traditional university. The students who were asked to participate in this study did not represent the entire student body, since not all students were required to take the course, College Mathematics and Algebra.

Assumptions

It was assumed that the Grasha-Reichmann Student Learning Styles Scales (GRSLSS) Inventory was appropriate for assessing the learning styles of students in this study. It was also assumed that the National Assessment of Educational Progress

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(NAEP) was appropriate for measuring students' mathematics achievement. A final assumption was that students would be honest and put forth their best effort when answering the questions on the assessments.

Summary

In this study, the relationship between student learning styles and achievement in an online mathematics course and a face-to-face traditional course were investigated. Brown (2011) noted learning style differences could exist between traditional face-to-face students and online students. It was posited by the researcher that if a correlation could be established between students who were successful in online classes by learning style classification, certain students could be advised to participate in online learning environments, and others might be advised against it. Instructors could be advised to adjust their online courses to accommodate the learning styles of students with the arrangement of an online class. Also, if a certain learning style prevailed as more successful than others in the online environment, teachers could make an effort to help students adjust to this learning style.

If a correlation was found to exist in this study of successful student learning styles in online and face-to-face classes, the mode of instruction (online or face-to-face) could be excluded as a variable to be considered in the campaign to raise mathematics achievement of students. Giving educators ideas on factors that can lead to improved practices for teaching online classes is imperative to the success of both students and

educators. If learning styles are a contributing factor in successful outcomes, students enrolling in courses and educators designing courses should take that into account.

Organization of the Study

In Chapter 1, the background of the problem, rationale and significance of the problem, purpose statement, theoretical perspective, and research questions that guide this study were presented. In Chapter 2, a review of the literature pertinent to this study is stated. Chapter 3 presents the rationale for the methodology, the population, the instrumentation, the data collection procedure, research design, and a summary of data analysis procedures. Chapter 4 contains a summary of the analysis of the data, and Chapter 5 includes a summary and discussion of the findings, implications for practice, and recommendations for further research.

CHAPTER 2
LITERATURE REVIEW

Introduction

This chapter has been organized to present, initially, the conceptual framework of
the study. In this first section, the relationship of learning styles and student achievement
is justified as an appropriate focus for the proposed research. The remaining sections of
this chapter provide the review of literature and related research supportive of the
conceptual framework. The second section of the chapter contains a detailed review of
the literature and research related to learning styles including (a) historical information on
learning styles, (b) models and instruments of measurement, and (c) instructional and
environmental preferences. The third section addresses online education with special
attention to mathematics. The fourth section of the literature review is concentrated on
academic achievement in general and more specifically on academic achievement of
mathematics students relating to learning style. The closer the literature relates to the
study, the more detailed the literature will be described. A summary concludes the
chapter.

Conceptual Framework

"Like scholarship, the practice of teaching must be grounded in a theoretical or
conceptual base" (Grasha, 2002, p. 90). Over the years, various learning theories in
education have been presented explaining how students attain knowledge, and educators
have relied upon these theories in designing their courses. The growth of online

instruction as an alternative to traditional face-to-face instruction has given rise to increased consideration of students' learning styles. This study was soundly grounded in the premise that the learning style of students may be an equally important variable to be considered by educators in the design of courses and delivery of instruction.

Analyzing the effects of learning style with online mathematics achievement was expected to lead to three distinct educational implementations. First, if learning style proved to be a significant factor, education techniques during earlier grades can enforce certain learning techniques that prove to be necessary for success. Second, knowing student learning style can also provide course designers with information to lead to student success in the course. Third, information on learning styles can also provide student advisors valuable information in regard to whether students are best suited for an online or a face-to-face instructional mode based on the student's learning style. Figure 1 provides a graphic display of the conceptual framework. It depicts the relationship between success in an online environment with student preparation, informed course design, and student advisement.

The enhancement of teaching and learning practices should be a priority in the development of instructional design (Jonassen, Davidson, Collins, Campbell, & Haag, 1995). When designing instruction, many variables are taken into consideration. Some theories emphasize different variables to which students' successful learning outcomes may be attributed. Many research studies on learning have recognized that students are dependent upon their methods of information processing and obtain information differently. The body of research focused on the differences in the ways in which

individuals perceive and process information is termed learning style theory (Husch, 2001) and was the basis of this study. Research on learning styles can prove to be valuable in that data on how students learn can lead to improvements in designing instruction for increasingly diverse students and modes of instruction available to them (Dzakiria et al., 2004).
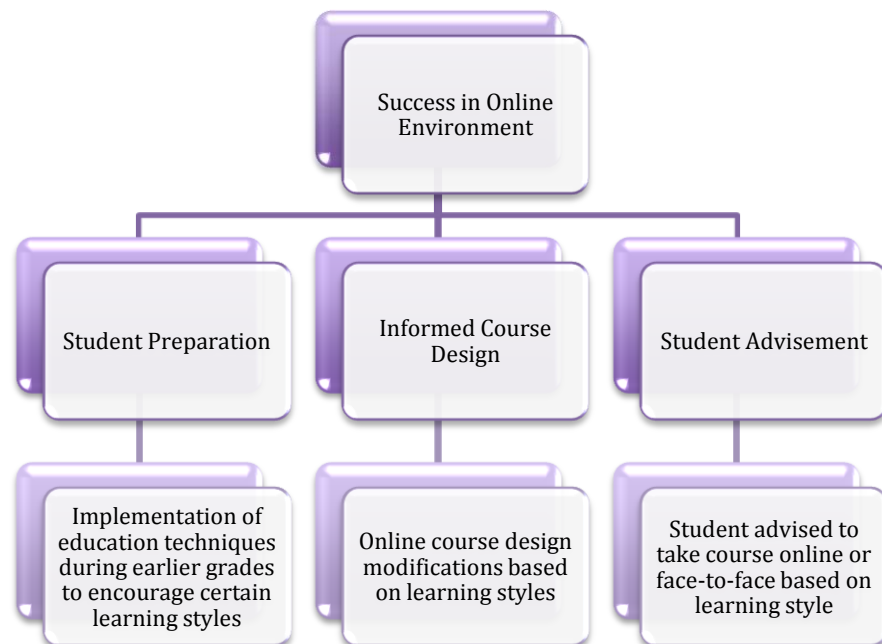
Figure 1. Conceptual Framework

The framework of this study incorporated the variable of student learning style. The identification of student learning style can help instructors develop conducive components to learning. Additionally, if a mode of instruction is keeping students from being able to learn, educators should address learning styles and try to find ways for these

students to learn (Merriam, Caffarella, & Baumgartner, 2006). This can play a role in deciding how to teach the course. Usually, teachers plan and design courses based on general assumptions about their prospective students (Grasha, 2002). Learning styles can provide the instructor with valuable information to consider in the design of a course about student differences from an information-processing and cognitive standpoint (Smith & Ragan, 1999). Hiemstra and Sisco (1990) noted that learning styles and learning methods must be considered in tandem for them to lead to student success.

Dunn & Griggs (1990) observed that there has been no common conceptual framework for the various learning style theories. Although this can lead to confusion and become problematic in improving instructional effectiveness, educators should not be discouraged from using what they learn from learning styles in their instruction (Dunn & Griggs, 1990).

In this study, Grasha's (2002) theory of learning styles served as the theoretical construct. His theory stated that college educators should know their students' learning styles and reflect on their teaching practices and techniques to meet the needs of their students. Grasha expressed the belief that taking learning style into account when developing course material can help college educators recognize gaps in both their instructional strategies and the ways students learn. Threlkeld and Brzoska (1994) presented similar views, stating, "A learner analysis of the potential audience should be conducted prior to course development. This learner analysis should include information about demographics, learner styles, motivations, and cultural background" (p. 54).

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Problems can arise when students are locked into any one learning style, because each style produces strengths and weaknesses. This study, therefore, emphasized certain characteristics of learning style that are exemplified by high achieving online students. If student learning style can help in identifying and classifying common characteristics of an assorted student population, courses may be designed to include components that will appeal to different learning styles and enhance the learning potential for more students. If, for example, one or more learning styles are found to be dominant for successful students in the online setting, and since learning styles can be learned over time (Conti & Welborn, 1986; Grasha, 2002), it may be useful to "teach" these styles to students throughout their education.

The conceptual framework for this study was grounded in the literature of learning style theory and its possible influence on student achievement, e.g., that students' learning styles should be considered as a variable in student success. If a particular learning style proves to be a contributing factor to the success of an online college mathematics student, students could be encouraged to use and develop this style to not only become more balanced and diverse learners (Silver, Strong, & Perini, 2007) but to be better prepared for their eventual enrollment in an online mathematics course.

Research conducted in regards to a particular conceptual framework can lead to an extension of the framework. "Recognition and acceptance that anything that happens in one part of the system affects the other parts is a necessary first step" (Moore & Anderson, 2003, p. 176). Researchers have upon occasion expanded their own theoretical frameworks to include further aspects of cultural and social interaction as they

are made clear (Bruner, 1991). This research was limited in its scope and considered learning styles used by online and face-to-face learners and the potential impact of those styles on academic achievement on both groups of students. If needed, additional theories can be included in the framework. It was posited that if, for example, elements such as the social-cultural nature of learning were found to be significant in student achievement, the work of Vygotsky could become integral to the conceptual framework. Depending on the results of this baseline study and future similar research, expanded theoretical bases could become part of an elaborated conceptual framework.

<center>An Introduction to Learning Styles</center>

The fact that students learn in different ways is not a new concept. Educators have long observed that students prefer certain methods of learning (Lawrence, 1984). The term *learning styles* has been used interchangeably with terms such as cognitive styles, thinking styles, and learning modalities (Mestre, 2006). Preferences that individuals have for instructional strategies have also been defined as learning styles (Jonassen & Grabowski, 1993). Riding and Rayner (1998) defined learning style as the preferred method by which an individual organizes and represents information. This study used one of the most common definitions, that of Keefe (1979) who defined the term as a collection of "cognitive, affective, and physiological factors that affect how learners perceive, interact with, and respond to the learning environment" (p. 4).

Some researchers have determined the examination of learning style to be vital because students learn best when they are educated through their own learning style

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(Gordon, 1995; Nolting & Nolting, 2008). In a meta-analysis of 42 learning style studies in which the learning styles of 3,181 participants were addressed, the standard deviation would be expected to be 75% higher for students whose learning styles would be accommodated (Dunn, Griggs, Olson, Beasley & Gorman, 1995). Gremli (1996) also noted that students learn much more comfortably when they receive information the same way they process the information. Even though students are capable of learning when instruction is given that does not use their preferred learning styles, higher test scores have resulted when students' learning preferences were used (Brudenell & Carpenter, 1990). Researchers have also shown that educators who individualize instruction by considering learning styles, facilitate their students' abilities to reach their full academic potential (Fleming, 2001; Fleming & Baume, 2006; Klasnja-Milicevic, 2011).

Some researchers have expressed the belief that learning styles are based mostly on biological components of an individual. Restak (1991) stated that biological components make up three fifths of the outcome for learning style. Dunn (1990) attributed the failure of some students in certain classes to their inability to adapt to a non-preferred learning style. Children can also reflect the learning styles of one parent, both parents, or neither (Dunn & Griggs, 1990; Milgram, Dunn, & Price, 1993). This explains the exceptional performance of one sibling and the lackluster or terrible performance of another sibling in the same school setting.

In contrast, Kolb (2000) described a learning style not as a fixed trait, but as "a differential preference for learning, which changes slightly from situation to situation, . . . at the same time, there is some long-term stability in learning style" (p. 8). Because

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styles have features that can be modified (Zhang & Sternberg, 2005), learning preference can change as students have new education and life experiences (Conti & Welborn, 1986; Sternberg & Grigorenko, 1997; Grasha, 2002). This has led to the suggestion that students can adopt and adjust to certain learning styles based on the way instruction is delivered (Grasha, 2002). According to Grasha & Yangarber-Hicks (2000), "Some learning styles are better developed and more likely to be preferred. The others are somewhat dormant, in need of exercise, and ready to surface with sufficient justification and support" (p. 4). Student learning style preference can change depending upon the subject the student is trying to learn (Jonassen & Grabowski, 1993).

Different researchers have expressed concerns regarding learning styles. Experts have argued that students should adjust to teachers' methods of instruction (Caine & Caine, 1991; De Bello, 1990). It has also been noted that students should learn how to manage when courses and material do not match their preferred learning styles (Felder & Spurlin, 2005). Another concern has been the lack of validity and reliability of instruments and overall consensus regarding theory (Kinshuk, Liu, & Graf, 2009; Kozhevnikov, 2007; Merisotis, 1999; Peterson, Rayner, & Armstrong, 2009; Sternberg & Grigorenko, 1997). With so many different instruments, definitions, concepts, and theories, the learning style research community has yet to form a consensus on these vital elements (Gray & Palmer, 2001). Also, the ways to transfer information gained from observing learning styles into practice are limited (Evans and Waring 2009; Gully and Chen 2010). Despite these concerns and criticisms, there has been support for the value of learning styles. Many researchers, such as Peterson et al. (2009), have been devoted to

its advancement in theory and research in the field, believing that style awareness is important to fully understanding students' performance in learning.

In investigating learning style differences, Zhang and Sternberg (2005) noted that discrepancies between students' learning style and educators' teaching styles could cause tension, conflict, and misunderstanding. If a student's learning style is not met it can also cause disengagement and lack of motivation (Silver et al., 2000). Felder (1996) stated that students' discomfort levels might interfere with their learning if they are restricted to only being taught in their less preferred learning styles. A dissonance can be created which consists of students being conflicted about the learning strategies they are using and the demands of their learning environment (Timarova & Salaets, 2011). A mismatch can result in students being less interested in the subject and learning less (Lage, Platt, & Treglia, 2000). Reiff (1992) argued that students could gain an appreciation for another style if their preferred styles are not being used. If, however, the experience is prolonged or particularly intense, students can become angry, stressed, and frustrated (Sternberg, Grigorenko, & Zhang, 2008). The styles mismatch can potentially lead to students being labeled as lazy or non-college bound, and result in their eventual referral to less demanding academic tracks (Soliday & Sanders, 1993). The misplacement on a track too early may not only damage student potential but lead to irreversible circumstances in students' education. The failure to understand and acknowledge these differences can cause unnecessary issues in the classroom.

According to Dunn (1997), "Researchers have clearly established that there is no single or dual learning style for the members of any cultural, national, racial or religion

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group" (p. 74). Yet Stiff (1990), noted that African-American students prefer to work in a holistic environment rather than memorizing and following rules in isolation. Researchers have also shown that addressing learning styles can be more productive for women, nontraditional, and minority students (Montgomery & Groat, 1998). Though some studies of learning styles and gender have been inconclusive (Philbin, Meier, & Huffman, 1995), other researchers (Severiens & Dam, 1994) have shown that gender plays a role in learning. Blum (1999), in her gender study, found that females preferred learning that incorporates empathy, relationships, and cooperation.

Several authors and researchers have discussed the value of students' understanding their learning styles. Bell (1998) wrote that students are able to study better and can improve their learning effectiveness if they know their learning styles. Fleming and Mills (1992) established that when students know their own learning styles, they are better able to reach their academic potential. Students who know their preferred methods of learning can better understand their strengths and weaknesses when approaching a course. This also encourages metacognition, as the students are made aware of their own thoughts and learning processes. Also, learners who are aware of different learning strategies can choose the best strategies for themselves if given a choice. Students have also been shown to demonstrate increased self-direction, responsibility and motivation when they know their learning style (Dunn & Griggs, 1995).

The relationship between conceptions of learning and learning styles can provide valuable student information for school of higher education (Richardson, 2011). Many

educators acknowledge that learning styles exist and have an impact on the learning process, but educators are not able to form an agreement about a single set of principles (Vincent & Ross, 2001) by which to assess styles. Therefore, many instruments exist to determine the learning styles of students. Even though many of these instruments have common characteristics, each instrument examines specific classifications of learners. The background of learning styles and some of the major learning style inventories are discussed in the following section.

Background of Learning Styles

In approximately 400 B.C., Hippocrates identified the essential differences in personalities of people and has been credited with being the first to examine and classify these differences. Learning style elements started to appear in research literature in the late 1800s in research that studied human behavior (Keefe, 1979). Some of these researchers were Pavlov, Watson, Freud, Adler, Rodgers, Maslow, and Jung. Jung was one of the first researchers to examine the patterns that individuals shared and classify them into groups. He first noted his thoughts on personality differences in a 1921 publication. Jung discussed personality traits in terms of four dimensions: introversion, extroversion, thinking, and feeling using two scales, the z-scale and the x-scale. The z-scale uses the introversion versus extroversion dimensions. The x-scale uses the thinking versus the feeling scopes. His theory takes the two scales and plots them two-dimensionally according to placement on the x-and z-scales. Jung (1921) also developed another scale, the y-scale, which took the two dimension model to a three dimension

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model. The y-scale measures an individual's sensing versus intuitive thought patterns. Based on his research, vision, and psychological types many personal inventories were born. These inventories are labeled as Jungian models.

Learning Style Models and Instruments of Measurement

There are different types of learning style models. Two models of particular relevance in this study were those of Raynor and Riding and Curry (Cassidy, 2004). The Rayner and Riding Model (1998) has three dimensions. The first dimension is personality centered and is based on personality traits. The second dimension is cognitive centered and is based on the learner's distinction in perceptual and cognitive functions. The third dimension is learning centered and involves preference-based and process-based models, e.g., information-processing models.

Many learning style instruments currently exist. This review addresses styles that are heavily used in educational research. The Curry Onion Model (Curry, 1983) compares learning style to the layers of an onion. The Onion Model displayed in Figure 2 provides a method of reviewing different learning style models and the instruments associated with the models. The layers, as layers of an onion, consist of cognitive personality, information processing, social interaction, and instructional preference. The deeper into the core of the onion the less that can be changed from an educational standpoint. The inner most layer is cognitive personality which is the personality of the student. The next layer is the information-processing layer. It defines the process by which information is stored, sorted, and obtained. The next layer is the social layer

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which addresses preference for socialization while learning such as working in a group or as an individual. The outermost layer, instructional preference, is the type of learning environment the student prefers.
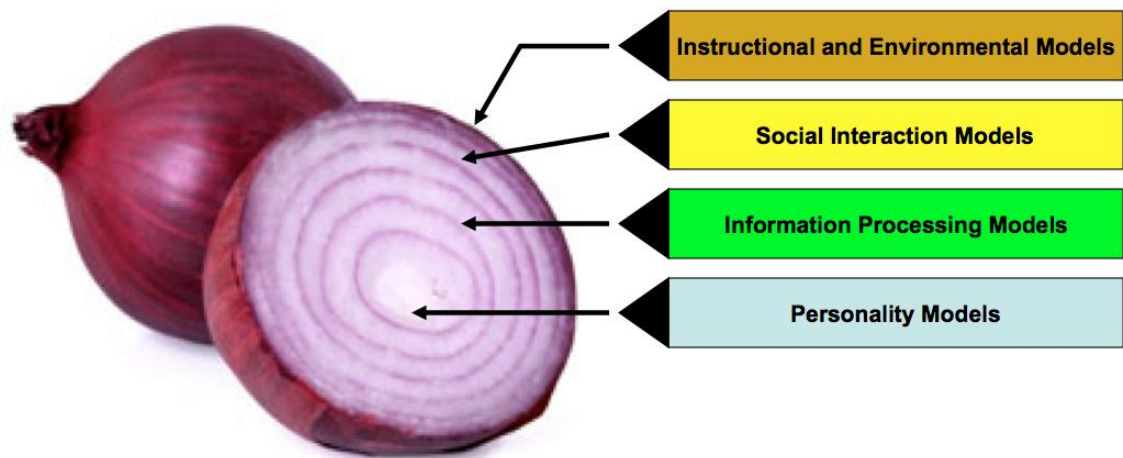
Note. Adapted from "An Organization of Learning Styles Theory and Constructs." By L. Curry, 1983, *Annual Meeting of the American Educational Research Association,* Montreal, Quebec.

Figure 2. The Curry Onion Model

Personality Models

Learning styles as a term is often used interchangeably with the term, cognitive styles (Merriam et al., 2006; Mestre, 2006); however they are different. Cognitive style is related to how one processes information or the mental process that occurs when one is learning. Cognitive style is not how the material is conveyed from educator to learner that affects learning. Rather, it is the resultant processing of information, using pure cognitive abilities, once in the learner's brain (Merriam et al., 2006).

In contrast, learning style identifies the most beneficial stimuli for the most effective use of a learner's cognitive style. Learning style indicators are different from cognitive tasks because they measure preference, not pure abilities. It is important this distinction is made as many learning style and personality models are at times described as cognitive models.

Several instruments based on personality models have been used to examine personality traits. Two of these instruments are the Myers-Briggs Type Indicator (Myers & McCaulley, 1985) and the Bates-Keirsey Temperament Sorter (Keirsey, 1987). Both instruments are based on Jung's theory and provide a personality inventory about psychological type preferences. The Myers-Briggs Type Indicator (MBTI) has four bipolar scales which consist of perceiving/judging, sensing/intuition, thinking/feeling, and extraversion/introversion which produce 16 personality types. The Bates-Keirsey Temperament Sorter is comprised of four temperaments: artisan, rational, idealist, and guardian. Each of these temperaments is divided into four categories. These models focus on differences of psychological type, and the instruments were not made to assess learning styles of students. These instruments are inappropriate to use as a learning style assessment for this study because they are personality instruments and were not constructed to investigate how information is learned.

Information Processing Models

Most learning style inventories belong to the information processing layer of the "Onion." They process how information is accumulated, classified, and attained.

Information processing models that were considered for this study include The Felder-Silverman Learning Style Model (Felder & Siverman, 1988), Kolb's Learning Style Inventory (Kolb, 1984), and the Honey and Mumford Learning Styles Questionnaire (Honey & Mumford, 1992). The Felder-Silverman Learning Style Model has four dimensions. The dimensions are active/reflective, sensing/intuitive, visual/verbal, and sequential/global. Kolb's Learning Style Inventory consists of rank ordering of four choices within 12 sets of statements. The outcomes are assimilator (theorist), converger (pragmatist), accommodator (activist), or diverger (reflector). Kolb, using his theory, examined student and teacher styles as they relate to their liking for reflecting on experiences, concrete experiences, creation of concepts and theories in relation to experiences, and using previous learned information to solve problems. The Honey and Mumford Learning Styles Questionnaire is a self-reporting instrument based on Kolb's model which is comprised of 80 agree/disagree statements. The outcomes are theorist, pragmatist, activist and diverger. These models are widely used in educational research but would not be appropriate for this study because none of the instruments have a social aspect. This aspect takes into consideration students' preferences for collective interactions with students when learning new information.

It is important to also consider various measures such as multiple intelligence and brain hemispheric research in the assessment of learning styles. Gardner's (1993) theory of multiple intelligences proposes seven primary forms: musical, linguistic, body-kinesthetic, logical-mathematical, spatial, intrapersonal, and interpersonal. The main difference between multiple intelligence theories and learning style theories is that

multiple intelligence focuses on the products and content of learning. In contrast, learning styles center on differences in the process of learning (Silver, Strong, & Perini, 1997b). Although these theories have not been focused on the same element, intelligence instruments have been used to determine the learning styles of students. The Herrmann Brain Dominance Instrument (Herrmann, 1988) analyzes information based on brain hemisphere. In 1983, Williams discussed brain hemispheric dominance. The left brain was described as analytic, rational, serial, and verbal. The right brain was described as visual, global, and holistic. This inventory consists of seven subscales. The four types are theorists, organizers, innovators, and humanitarians. As with the other information-processing models, these models would not be preferred for this study because of the lack of social information, an important factor when observing the learning styles of students enrolled in online and face-to-face courses.

Social Interaction Models

The social layer addresses preference for socialization while learning. In 2005, Muilenburg and Berge conducted a study on barriers to online education. Social interactions emerged as the greatest barrier (Muilenburg & Berge, 2005). Grasha (2002) addressed this social interaction in his definition of learning style as the "personal qualities that influence a student's ability to acquire information, to interact with peers and teacher, and otherwise to participate in learning experiences" (p. 41). The main objective of the Grasha-Riechmann Student Learning Style Scales (GRSLSS) is to identify the preference that learners have for interacting with the instructor and their

peers in the classroom (Grasha, 2002). The GRSLSS is the learning style inventory that was used in this research.

The instrument was developed in the early 1970s and is comprised of 60 Likert-type questions and 10 indicators for each of six learning styles. The expectation is that everyone completing the instrument will be determined to possess a little of each of the characteristics mentioned in the learning styles, but individuals will gravitate toward one or two certain learning styles. According to Grasha and Yangarber-Hicks (2000), the six learning styles can be viewed as colors on an artist's palette. "All of the colors are present within our personality, but some blend more readily, and some are more dominant than others" (p. 4). The goal, then, will be to determine those learning styles of students that are deemed "dominant".

The six learning style categories are independent, dependent, competitive, collaborative, avoidant, and participant. Table 1 provides a description of the six learning styles, the classroom preferences, and the perceived advantages and disadvantages of each.

Table 1

The Grasha-Riechmann Student Learning Styles

Learning Styles Description, Classroom Preference and Advantages and Disadvantages

Independent

Students who like to think for themselves and are confident in their learning abilities. Prefer to learn the content that they feel is important and would prefer to work alone on course projects than with other students.

Classroom Preferences - Independent study, self-paced instruction, assignments that give students a chance to think independently, projects that students can design, student-centered rather than teacher-centered course designs.

Advantages - Develop skills as self-initiated, self-directed learners.

Disadvantages - May become somewhat deficient in collaborative skills. Might fail to consult with others or to ask for help when it is needed.

Dependent

Show little intellectual curiosity and who learn only what is required. View teacher and peers as sources of structure and support and look to authority figures for specific guidelines on what to do.

Classroom Preferences - Outlines or notes on the board, clear deadlines and instructions for assignments, teacher-centered classroom methods, as little ambiguity as possible in all aspects of course.

Advantages - Helps them to manage their anxiety and obtain clear directions

Disadvantages - Difficult to develop skills for exhibiting autonomy and self-direction as a learner. Does not learn how to deal with uncertainty.

Competitive

Students who learn material in order to perform better than others in the class. Believe they must compete with other students in a course for the rewards that are offered. Like to be the center of attention and to receive recognition for their accomplishments in class

Classroom Preference - Group leader in discussions, Teacher centered instructional procedures, singled out in class for doing a good job, class activities where they can do better than others

Advantages - Motivates student to keep up and to set goals for learning

Disadvantages - May turn less competitive people off and style makes it more difficult for people to appreciate and to learn collaborative skills

Learning Styles Description, Classroom Preference and Advantages and Disadvantages

Collaborative

Typical of students who feel they can learn by sharing ideas and talents. They cooperate with teachers and like to work with others.

Classroom Preferences - Lectures with small group discussions, small seminars, student designed aspects of courses and group projects

Advantages - Develop skills for working in groups and teams

Disadvantages - Not as well prepared for handling competitive people. Depend too much on others and not always able to work alone

Avoidant

Not enthusiastic about learning content and attending class. Do not participate with students and teachers in the classroom. They are uninterested and overwhelmed by what goes on in the class.

Classroom Preferences - Generally turned off by most classroom activities, would prefer no test, pass-fail grading systems, does not like enthusiastic teachers, does not want to be called on in class

Advantages - Able to avoid the tension and anxiety of taking serious steps to change their lives. Has time to do enjoyable but less productive task.

Disadvantages - Performance drops and negative feedback acts as another reminder of their failings. Keeps them from setting productive goals.

Participant

Good citizens in class. Enjoy going to class and take part in as much of the course activities as possible. Typically eager to do as much of the required and optional course requirements as they can.

Classroom Preferences - Lectures with discussion, opportunities to discuss material, class reading assignments, teachers who can analyze and synthesize information well.

Advantages - Gets the most out of every classroom experience

Disadvantages - May do too much or put others' needs ahead of their own

Note. Two merged tables adapted from *Teaching with Style*, by A. Grasha, 1996, San Bernadino, CA: Alliance Publishers.

Independent students prefer self-paced instruction, to work alone, and to study independently. They prefer assignments that allow them to express their own ideas. They often believe their ideas are as good as those of their instructors, and they like to

find out more about topics that interest them and study what they feel is important regardless of what the teacher says is important. Independent learners are confident about their ability to learn on their own and have ideas about how the class should be conducted (Grasha, 2002).

Dependent students prefer an authoritative figure to tell them what to do and seek the teacher and peers as a foundation of guidance and structure. They prefer specific instructions for assignments, clear deadlines and as little ambiguity as possible. They rely on the teacher to tell them what is important for them to learn and dislike making choices about their own learning. They only do what is required in the class, take verbatim notes, and complete assignments exactly as instructed (Grasha, 2002).

Competitive students are motivated to learn so as to receive acknowledgement for academic success and learn to outperform their peers. They tend to be group leaders, want to be the first one to solve problems, try to win the teacher's attention, are interested in how well others do on assignments, and want recognition for their achievements (Grasha, 2002).

Collaborative students learn by working together with teachers and peers. They like working in small groups, having discussions, and completing group projects. They feel they can learn by sharing talents and ideas with peers. They enjoy helping classmates with course materials, small group discussions, studying for tests with other students, working on group projects, and feeling like part of a team (Grasha, 2002).

Avoidant learners are not enthusiastic about learning the class material or attending class. They are frequently overwhelmed by class assignments and not

interested in the course. If they attend class, they often socialize with classmates nearby, daydream, cram for exams, do not participate in class, and give up on learning anything in the course (Grasha, 2002).

Participants are fond of class and make good contributors to the course. They enjoy class activities, discussion, and enjoy completing class assignments. They take responsibility for their own learning, doing whatever is asked of them. They complete all assignments, even optional ones. They prefer teachers who are excellent at analyzing information (Grasha, 2002).

The categories, model type, age and validly of the GRSLSS, concluded in this learning style inventory being used for the study. James and Gardner (1995) emphasized the importance, in selecting a learning style instrument, of matching the instrument to its intended use and the intended use of the data to be collected. The GRSLSS instrument was constructed for use with high school and college students. It factors in social interaction as part of student learning style. Grasha (2002) described his instrument as using "a variety of cognitive, social factors, motives, emotional, problem solving abilities, memory and perceptual processes, and information processing capabilities to identify and label the learning styles of students" (p. 41). This instrument is also one of the few learning styles inventories that has adequate reliability and validity (Curry, 1983) and will be further discussed in Chapter 3. The GRSLSS was determined to be the best choice for this study in which the learning styles of postsecondary students in different social environments, online and face-to-face, were addressed.

Instructional and Environmental Preference

Instructional and environmental preference are concerned with the type of learning environment students prefer. Instruments that fall in this category are the Canfield Learning Styles Instrument (Canfield & Knight, 1983), Dunn and Dunn Learning Style Model (Dunn & Dunn, 1978), Gregorc Style Delineator (Gregorc, 1984), and Gagne Conditions of Learning (Gagne, 2004). The Canfield Learning Styles Instrument is self-reporting and has thirty clusters of four statements that are to be rank ordered. There are seven different rankings available for conditions, three for content and four for mode. The Dunn & Dunn instrument consists of 100 Likert-type scales. The results are related to environmental, sociological, emotional, psychological, and physiological factors. The Gregorc Style Delineator instrument focuses on the auditory, tactile/kinesthetic, and visual aspects of students. This self-reporting instrument consists of 10 sets of four items to be ranked. The test has two dimensions: sequential-random and concrete-abstract. Gagne's (1985) research on conditions of learning theory has had a particular impact on learning in mathematics education. His framework organized learning into five categories: verbal information, intellectual skills, cognitive strategies, motor skills, and attitudes (Gagne, 1985).

Many different learning style inventories exist and have been reviewed in this chapter. After reviewing the varied approaches to learning styles and the literature, the Grasha-Riechmann Student Learning Style Scales (GRSLSS) was determined to be the learning style inventory that was most appropriate for use in the proposed study because it includes the variable of social interaction.

Online Education

The fastest growing phenomena in higher education at the beginning of the 21st century was online instruction (Beaudoin, 2002). Online education has made the Internet a valuable tool for educators, students, and schools (Merriam, 1998). The rapid increase in Internet usage has posed a challenge to traditional ways of teaching and learning (Watson, 2007). Many of the technological developments in the 20th century such as radio, records, television, and film were disappointments in teaching because teaching and learning continued to depend primarily on old technologies, i.e., print sources (Arsham, 2002). The use of new tools such as podcasts, text, pictures, tweets, blogs, virtual worlds, and video has increased with the growth of online instruction and the ease with which such tools can be accessed by instructors and students. Also, with the increased popularity of mobile technology devices such as Blackberrys and iPhones, there is every reason to believe that the future of online learning could shift from computer to mobile technology (Johnson, Smith, Willis, Levine, & Haywood, 2011; Uzunboylu, Cavus, & Ercag, 2009). This way of learning is known as ubiquitous learning or u-learning (Liu & Hwang, 2010).

In terms of current postsecondary online course offerings and student enrollment, in a report for the Sloan Consortium, Allen and Seaman (2010b) stated the following seven statistics.

- In 2010 63% of all reporting institutions said that online learning was a critical part of their institution's long-term strategy.
- The year-to-year change was greatest among the for-profit institutions, which increased from 51% agreeing in 2009 to sixty-one percent in 2010.

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- Over 5.6 million students were taking at least one online course during the fall 2009 term; an increase of nearly one million students over the number reported the previous year.
- The 21% growth rate for online enrollments far exceeds the less than two percent growth of the overall higher education student population.
- Nearly 30% of higher education students now take at least one course online.
- About 66% of academic leaders rated the learning outcomes in online education as the same or superior to those in face-to-face.
- Virtually all recent growth in online enrollments has come from the growth of existing offering, not from institutions new to online starting new programs (p. 2)

With the increase in online courses more research should be done in the area of student achievement.

No common argument for effective online teaching pedagogy has been offered (Engelbrecht & Harding, 2005a). Many institutions have produced learning and teaching centers whose main objectives are to incorporate ground-breaking pedagogies into teaching, but teaching online courses generally takes a back seat in these centers (Grasha, 2002). In order for online educators to gain knowledge about teaching online, research of practicing online faculty must be conducted. Only then can recommendations be given (Morris, Hu, & Finnegan, 2005). This will also contribute to identifying superior online pedagogy (De Simone, 2006).

Evaluating methods of recruitment, advisement, and course delivery in online classes can assist universities in selecting populations that will be successful in online classes and least likely to drop out (Dziuban, Moskal, & Dziuban, 2000). In the early days of online education, many students, educators, and administrators were skeptical (Kearsley, 1999) about its effectiveness. Universities have, however, dedicated

substantial financial resources and time to provide students with the ability to access a course anytime and anywhere by providing online courses (Watson, 2007).

Many universities and organizations have made public a list of necessary characteristics and qualities to be considered for a successful online student. Some researchers have taken the position that "anecdotal research indicates that the most successful online students are highly self-regulated learners who require little in the way of formal lesson design" (Tallent-Runnels et al., 2006, p. 109). Other researchers have shown that students who are insensitive to a social undercurrent and are more individualistic are best suited for the online learning environment (Liu & Ginther, 1999). Characteristics of successful online students include, but are not limited to, having confidence, being an active communicator, possessing knowledge of learning style, and being both self-disciplined and self-motivated (Boyd, 2004). Kearsley (2002) stated that to be successful in an online course students need a lot of initiative and self-discipline.

In a list of best practices in online teaching, Palloff and Pratt (2003) noted that educators should understand how their students learn and what their students need to support their learning. They should then find a way to involve the students in the course design and assessments. Unfortunately, many educators teach the way they were taught and do not consider the different learning styles of the students in their class (Dunn & Dunn, 1993). Since the ways individuals develop behaviors and attitudes, solve problems, and make decisions are all affected by learning style (Kolb, 2000), determining general characteristics and learning style of one's students has been judged to be an excellent basis on which to design an online course (Du & Simpson, 2002; Knowlton &

Thomeczek, 2007). Mupinga, Nora, and Yaw (2006) cited the importance of sensitivity to learning styles as follows: "To maximize the students' learning experiences, instructors need to be sensitive to learning styles" (p. 185). Palloff and Pratt (2003) discussed the advantages of various online course management systems in providing the possibility for online courses to address various learning styles. Course management systems can allow students of one learning style to be guided through the course using one set of instructions and particular resources and activities. At the same time, students with other learning styles are afforded the same opportunities—all pertaining to the same learning objectives. Also, the way an online course is presented can be structured to provide support for various social, sensory, and learning styles of students (Ross & Shulz, 1999). Educators should incorporate activities that use different learning styles so that all students can have the advantages needed to maximize their academic achievement (Kolb & Kolb, 2005).

Studies have been conducted using learning styles to distinguish between successful and unsuccessful online students (Anderson & Adams, 1992; Sullivan, 1998; Wells, 2000). Gordon (1995) recognized the need for additional research and recommended that more research be conducted on online students using various learning style instruments. Schrum and Hong (2001), in their study of 70 institutions, found that access to tools, technology experience, study habits, goals, learning preferences, purposes, lifestyles, and personal traits affected the success of online students.

Many different disciplines have been discussed in the literature involving learning styles and online education. Most learning styles research has been focused on

achievement outcomes, dropout rates, attitudes about learning, and predictors of high risk

students (Diaz & Cartnal, 1999b). Only limited research has been conducted on learning

styles and asynchronous learning environments, where the communication between

educator and learner does not occur in real-time. Research in this area, however, has

been steadily increasing (Fahy & Ally, 2005).

An element to examine when looking at online courses is the physical isolation of

the learners from their classmates and the educator. Willging and Johnson (2009)

reported problems students have with online courses. One of the major issues has been

the lack of interaction with other students. Physical presence, nonverbal cues, vocal

inflection, body language, facial gestures are all lacking in the online environment. This

lack of social interaction can be problematic for some students who prefer the eye

contact, body language and other human factors that occur in a classroom (Hopper,

2001). Jung et al. (2002) measured the effects of collaborative, academic, and social

interaction on learning, participation, satisfaction, and attitude towards online learning.

The students were divided into three groups: (a) the academic group which only

interacted with the teacher about content related matters, (b) the collaborative group

which had the same guidelines as the academic group plus participation in online

discussions and working collaboratively on assignments, and (c) the social group which

exhibited all the characteristics of the collaborative group and also received immediate

feedback from the instructor. The results indicated that the social group scored

significantly higher on assignments. As Russo and Benson (2005) stated, online learning

is "learning with invisible others" (p. 54). This can be a challenge for some learners, as

studies have shown that lack of social interaction is a primary concern of online learners

(Muilenburg & Berge, 2005). Also, real time feedback is missing as the educator and

students are able to access the course at any time.

> The ability to learn and teach anytime, anyplace presents a flexibility not found in more traditional modalities--a flexibility that challenges faculty to foster a sense of community that might be more organic than in a setting where faculty and students meet face-to-face on a regular basis. (Bush, Dzuiban, Moskal, & Wang, 2005, p. 5)

Online courses do provide advantages in some respects. Students can ask one-on-

one questions to the teacher without the constraints of time that would be found in a face-

to-face course. This has been found to help students acquire a deeper level of conceptual

understanding (El Mansour & Mupinga, 2007; Pyon, 2008). Researchers have indicated

that online courses are great for effective classroom teaching, e.g., rapid feedback, time

on task, and content expertise (Hopper & Harmon, 2000). In some instances, however,

the time between corrective feedback or answers can cause the student to get behind or

become unmotivated and distracted because of the linear structure of some courses

(Smith & Ferguson, 2004).

Tu and McIsaac (2002) cited gender, learning style, and online communication

competency as factors influencing the learning experience of students in online courses.

Sims and Sims (1995) addressed the importance to instructors of knowing how students

learn and understanding the various potential of diverse course elements. "If we are to

understand how to support cognitive presence in online and blended learning

communities, then greater focus needs to be placed on linking processes and outcomes"

(Akyol & Garrison, 2011, p. 2). The present study was conducted to add to the body of

knowledge which instructors may access as they reflect on their prior experience and plan for future instruction in online and face-to-face courses.

Mathematics Online

The notion that the use of curricula that promotes conceptual rather than procedural understanding may be attributed to the growing online environment is particularly true relative to mathematics (Juan, Steegmann, Huertas, Martinez, & Simosa, 2011). There are many benefits for students taking mathematics courses online. They have more opportunities for individualized instruction (Trenholm, 2007), mastering learning (Lindsay, 2006), as well as time on task for repetition and learning new material (McCabe, 2007). Obstacles do exist, however, when teaching a mathematics course online. There is a gap in research in regard to mastery learning in an online undergraduate mathematics class (Engelbrecht & Harding, 2005b; Ford & Klicka, 1998). This study will add to the current literature on online undergraduate mathematics courses and will contribute to closing the gap in research.

Mathematics pedagogy for online courses is still in a developmental stage (Engelbrecht & Harding, 2005b), and there are a number of potential problems associated with mathematics online instruction. Faculty who are not provided with training when designing their online courses may simply transfer their face-to-face class format to the online format without appropriate modifications (Bernard, Abrami, & Lou, 2004; Mupinga & Maughan, 2008). Other obstacles are related to the limited availability of mathematics texts written for self study (Allen, 2003) and the potential for academic

dishonesty of students enrolled in online classes (Trenholm, 2007). Also, not all excellent classroom teachers make good online teachers (Kersley, 2002).

Communication in teaching mathematics online can be very difficult due to the symbolic and graphic nature of the subject (Miner & Topping, 2001; Smith & Ferguson, 2004). Many of the commercial learning management systems (LMS) that universities use to provide online courses to their students are barely adequate to address the symbols and other graphics needed for a mathematics course when these platforms are constructed (Smith, Torres-Ayala, & Heindel, 2008), and critics have argued that technology has not provided for effective communication in the teaching of mathematics online (Smith et al., 2008). This deficit in symbolic tools can lead to frustrated students who are limited in their ability to ask instructors questions via email (Smith & Ferguson, 2004).

Smith (2008) interviewed 20 experienced online mathematics teachers and asked them to share the challenges of teaching mathematics online. They stated that the sequential nature of mathematics, the abstractness of concepts, the visual-spatial components, the necessity of the instructor to model problem solving, the unique set of symbols, and academic integrity as presenting the most demanding responsibilities in the teaching of mathematics online. Other difficulties were associated with the anxiety students experienced due to the abstractness of mathematics as they worked out problems.

Academic Achievement

Feemster (1999) observed that one of three college students do not return after their freshman year. There have been numerous reasons cited and much research conducted to explain students' success, lack of success, or lack of motivation in regard to their academic achievement (Dunn & Griggs, 1995). Being attentive to learning styles has been noted as one positive step to improving retention rates of college students (Federico, 2000).

Knowing, working, and teaching with students' learning style as a guide can result in increased academic achievement and more positive attitudes toward learning (Dunn, Griggs, & Price, 1993; Ewing & Yong, 1992; Sternberg & Grigorenko, 1997). The learning outcomes regarding learning style in online and face-to-face classroom environments have been both positive and negative. Many studies have been conducted to investigate the relationship between learning styles and academic achievement (Desmedt & Valcke, 2004). Following is a discussion of the results of a few of the studies which have been conducted to investigate and compare student achievement in face-to-face and online classrooms.

Grasha and Yangarber-Hicks (2000) studied student achievement and learning styles of students in both traditional face-to-face classrooms and technology-enhanced classrooms. In the study, the Grasha-Riechmann Student Learning Scale was used to measure learning style, and the final grade was used as a measurement for student achievement. Students who received the better grades in both settings had high collaborative, independent, and participant styles.

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In a 2004 study, later published in 2008, Akdemir and Koszalka investigated 12

students enrolled in an online graduate course entitled Design and Management of

Distance Education to see if matching or mismatching student learning style would

support the student learning. The Psychological Differentiation Inventory was used to

measure the students as field dependent or field independent. Three modules were used

in teaching the course, and each used a different instructional strategy: (a) expository

(presentation), (b) collaborative (group work), and (c) inquisitive (discovery learning).

The results indicated there was no benefit in matching and/or mismatching students with

their learning style.

In contrast, Liu (2007), using a small sample of students (n = 19), concluded that

online instruction was significantly affected by learning styles. The students participating

in this study were enrolled in a graduate level Educational Research course. A number of

additional studies have been conducted in which it was determined that learning style

plays a significant role in online academic achievement of online students (Cassidy,

2004; Fahy & Ally, 2005; Nastanski & Slick, 2008).

Dille and Mezack (1991) used Kolb's Learning Styles Inventory to predict the

success of community college students. Significance was shown for students enrolled in

a telecourse who earned a C or better if (a) their locus of control was internal, (b) their

learning style supported looking into abstract concepts to find why certain things

happened, (c) they were self-disciplined, and (d) they exhibited an independent learning

preference. In comparison to online courses, telecourses do not require the student to be

present at a certain location or view course material at the same time as other classmates. In contrast to online courses, telecourses are provided via television and not via Internet.

Researchers have found that field-independent students are logical, more analytic, and better at solving abstract problems (Bernt & Bugbee, 1993). Field-dependent students, however, have been determined to learn best when working with others to receive guidance, information, and help in maintaining their attitudes. According to Jonassen & Grabowski (1993), when taking an online course, regardless of subject, field-independent students performed significantly better than the field-dependent students. These researchers indicated that field-dependent students might have learning difficulties if they do not have adequate opportunities for discussions and personal contact.

Learning styles, student characteristics, and patterns of learning were investigated to determine what factors influenced students' online learning (Shih, Ingebritsen, Pleasants, Flickinger, & Brown, 1998). The Group Embedded Figures Test was used to observe the learning style of 74 undergraduate students. Results indicated that learning styles did not have an effect on the students' learning achievement.

In an earlier study, the Canfield Learning Styles Instrument was used to show that learning style affected attitude and academic achievement for a distance education course (Gee, 1990). Students who were independent, conceptual learners scored higher. The social, conceptual learners scored the lowest in terms of academic achievement.

The review of literature revealed a general lack of attention pertaining to learning styles in online education. In comparing online courses and face-to-face courses,

learning styles have been shown to have both significant effects and insignificant effects on student achievement and student satisfaction (Manochehri & Young, 2006).

In 1999, Diaz and Cartnal found differences in the average scores of students when their learning styles were taken into account. The study participants included 40 online students and 63 face-to-face students in a health education course. Using the Grasha-Reichmann Student Learning Style Scales, the researchers found that the independent students and dependent students had significantly different scores. The online independent students, those who preferred self-paced instruction and independent study, scored higher than did dependent students. Though successful online and face-to-face students both possessed a conceptual learning style, the differentiating factor was that students with higher scores had an independent learning style and the students with lower scores had a social and dependent learning style. It was also shown that online students were more intrinsically driven than were students experiencing the reward structure of the face-to-face class. Diaz and Cartnal also noted, "if optimal learning depends on learning styles, and the styles vary between distance and on-campus students, faculty should alter their preparation and teaching accordingly" (1999b, p. 132).

Gee (1990) compared a total of 23 female graduate education students' achievement in a telecourse with that of an identical population enrolled in a face-to-face course. Using data from the Canfield Learning Style Inventory, Gee found that students with the highest average scores in the telecourse possessed a learning style that led to a more independent and conceptual learning preference. The lowest performing telecourse students had a social learning style. The face-to-face students with the highest average

achievement exhibited a social learning style and preferred an applied learning environment.

A number of studies have been conducted in the early 21st century which yielded no significant findings regarding courses taught face-to-face or online (Aragon et al., 2002; Caywood & Duckett, 2003; Christopher, Thomas, & Tallent-Runnels, 2004; Neuhauser, 2002; Peterson & Bond, 2004; Thirunarayanan & Perez-Prado, 2001). These studies, in which online instruction was proposed to be as effective as face-to-face instruction, used a variety of undergraduate college students, different methodologies, and measures of student achievement.

Gunawarden (1993) observed four graduate classes: one online and three face-to-face. Using Kolb's Learning Style Inventory and a small sample size, he showed that student learning styles did not play a role in students' interaction with the media and methods of instruction.

Aragon, Johnson, and Shaik's (2002), in their study, examined two graduate instructional design courses. One of the courses was face-to-face, and the other was online. Although there was significance found between the learning style preference of the online student and the face-to-face students, there was no significant difference between the two courses when success factors were controlled. In another study (Akdemir & Koszalka, 2008), only online students were investigated, but no significant differences were determined in the research on these students' learning styles and achievement.

Academic Achievement of Mathematics Students Relating to Learning Style

Studies have been conducted on the relationship of mathematics achievement and learning style (O'Brien, 1994). However, mathematics education reform has not been particularly attentive to learning styles (Griggs, 1991), but learning styles have been considered in the development of instructional strategies used for intervention in mathematics classrooms (Strong, Thomas, Perini & Silver, 2004). Dunn and Dunn (1992) found that many adult learners are kinesthetic or tactile but that many mathematics teachers are visual. This can pose some challenges in teaching adult learners if learning style is not taken into consideration.

There have been very few studies focused on mathematics achievement and online courses. Mathematics has been viewed as a purely conceptual subject, and many educators have expressed the belief that face-to-face courses are needed to teach these concepts (Engelbrecht & Harding, 2005a). Others have supported the notion that mathematics concepts can be taught online using the Internet by creative educators using easy-to-illustrate instructional strategies (Malone & Bilder, 2001). Galindo (2005) stated that the Internet aids in the teaching and learning of mathematics and lists many resources that are available for this use. Following are reviews of a number of studies on student achievement in relation to teaching mathematics and learning style.

In terms of brain dominance, a study conducted by Rooney (1991) involved students enrolled in nine Calculus I sections. Students who had left brain dominance scored significantly higher grades than the right brain dominant students. It was also

found that right brain dominant students were three times as likely to withdraw or receive a failing grade.

A study of 23 developmental mathematics students used the Myers-Briggs instrument to determine if learning styles affected student achievement in the course (Matthews & Newman, 1994). Students were divided into two categories in which students' learning styles were compatible or non-compatible with the mode of instruction. The results showed that learning styles did not significantly affect the achievement of students. A recommendation of the researcher was that educators should use a variety of instructional techniques to help students with different learning styles but should not change instruction to appeal to one learning style.

Wetzel and Harmeyer (1997) conducted a study comparing the learning styles of high-learning and low-learning algebra students. High-learning students refers to students taking mathematics courses in Trigonometry through Differential Equations. Low-Level refers to students taking remedial mathematics courses. They found that low-level students had more diverse learning styles and high-level students had learning styles closer to those of their educators. A total of 92.9% of the educators were assimilators or accommodators. Of the high-achieving students, 72.5% were assimilators or accommodators, and 62.5% of the low level students were divergers or convergers. The study also showed that statistically the accommodators and assimilators were more likely to take an advanced mathematics course.

Treacy (1996) researched the relationship between learning styles, feelings, and beliefs about technology and mathematics achievement of 377 secondary students. She

found (a) a significant correlation between learning style and feelings and beliefs about technology and (b) a significant correlation between mathematics achievement and learning style. She also found that feelings about technology played a role in predicting mathematics achievement.

Several authorities have indicated the importance of considering learning styles in planning for online instruction. Hopper (2001) noted that many teachers will merely convert their face-to-face course when designing an online course because of the lack of online pedagogy availability, especially in the realm of mathematics courses. As early as 1987, Claxton and Murrell advocated the use of learning styles as an important tool for the development of courses in higher education. Souder (1993) recommended that future researchers consider being attentive to learning styles in online courses.

A limited number of studies were identified in the review of literature and related research that addressed the relationship between learning style and computer-based and online mathematics courses. A discussion of these studies which were particularly relevant to the present study follows:

Jai (1994) investigated the relationship between attitude toward computers, learning styles, and mathematics achievement. His study involved 101 undergraduate mathematics students whose laboratory consisted of computer assisted instruction (CAI). The students' learning styles were determined using the Gregorc Style Delineator. In relation to learning styles and mathematics achievement, the study showed no significant difference between the sequential and random learners, but concrete learners did significantly outperform abstract learners.

In Clariana's 1997 study, 30 college developmental mathematics students were given the Kolb Learning Style Instrument to determine if learning style was a factor in students' final grades in a course modified to use computer assisted instruction. The concrete experimental learners were more successful with the mode of instruction. It was also noted that the change in modality may cause a personality shift from abstract to concrete learning tendencies.

In 1988, Bell conducted a study to see if student learning style would determine success in an online mathematics course. He gave the Learning Style Inventory to 40 business mathematics students who were classified as either visual, auditory, or tactile learners. The final grades of the visual learners were significantly higher than those of the tactile and auditory learners. Bell believed that these results were due to the fact that a majority of the course was taught using visual/aural mode and that students with that learning style did better because the course was taught in that mode.

There has been limited research into online and face-to-face mathematics instruction, academic achievement of students, and comparisons of the respective variables (Engelbrecht & Harding, 2004, 2005a). In the comparison of student achievement in online versus face-to-face mathematics courses, varying results were found.

Smith (1996) researched 244 community college students on the effects of learning style and mathematics achievement. The Gregorc Style Delineator was used to measure learning style. After the students were tested, they were placed into one of three groups for a presentation of Matrix Algebra. One group's presentation used textbook

passages; another group used static computer-aided instruction; and the final group used animated computer-aided instruction. The students were tested at the conclusion of the presentation and again two weeks later. Though there was no significance between the treatment type and learning style, concrete random students significantly outperformed the students belonging to any other learning style on both the pretest and the delayed test. The concrete sequential students received significantly lower scores on the test administered immediately following the Matrix Algebra presentation than did students of the other learning styles.

Esmaeili (2001) conducted a study of 137 Mexican American students spanning six undergraduate algebra courses. Four of the sections were taught face-to-face and two sessions were taught online. The course grades for both modalities were analyzed. The results were that the students in the face-to-face class performed significantly better than did the online students.

In another study, the modalities of face-to-face, telecourse, and online of a community college introductory mathematics course were studied (Ryan, 2001). The telecourse was broadcast on videotape as well as online. Using the final course grade as a measure of achievement, no significant difference in student achievement was found based on the modality of the course.

In a study by Weems (2002), the difference in performance of 48 beginning algebra students taught in an online mode versus a face-to-face environment was researched. A total of 25 students were enrolled in the online section, and 23 were enrolled in the face-to-face section. There was no significant difference between the two

formats in regard to student achievement. The study showed a significant decrease in examination scores of the online students from the beginning to the end of the course, but no decrease was found for the face-to-face students. The study also indicated that 19% of the students researched stated that lack of interaction in the course was a limitation to their learning process.

Abrams and Haefner (2002) performed a qualitative study on students' main reasons for taking a mathematics class online rather than face-to-face. The students who preferred the online courses liked the fact that they had an isolated work environment during the lecture and were not distracted by classmates. They also enjoyed the convenience of not having to take notes because they were posted for the online course. Students who preferred face-to-face classes associated learning with face-to-face interaction and needed a social environment. This study was directly related to students' learning styles based on the observed preference for social interaction as opposed to an isolated environment.

Manochehri and Young (2006) conducted a study that had statistically significant results when researching learning style and achievement. This study examined 36 online and 58 face-to-face undergraduate mathematics students. The Kolb Learning Style Inventory was used to measure students' learning styles, and a final course examination was used to measure student achievement. There was a significant difference in achievement based on the students' learning style in the online mode, but the same was not true for the face-to-face mode. Students exhibiting the assimilator and converger

learning styles did better in the online mode. Students who had the diverger and

accommodator learning styles achieved higher scores in the face-to-face class.

Most of the literature reviewed on mathematics achievement and learning style

was concerned with the implementation of instruction that would appeal to different

learning styles and, therefore, potentially improve outcomes for students. This study was

conducted to investigate learning styles as they related to actual student achievement

outcomes. As Liu stated, "There is still not enough literature regarding the experimental

effects of online instruction on online students and learning styles" (p. 42). Researching

this aspect was intended to not only provide additional research to the body of literature

but to provide an enhanced outlook regarding the literature that currently existed on

student learning styles and student achievement at the time of the present study.

<div align="center">Summary</div>

An essential question for educators to ask is if their students will learn better

when instruction is aligned with the student's learning style (Mayer, 2011). Students

deserve the opportunity to learn so they can reach their educational goals. One way this

can be accomplished is to embrace the notion that not everyone learns the same way.

Learning is believed to happen through a personal individualized act of feeling and

thought (Silver et al., 1997a).

Instructors' understanding of the learning styles of their students can be a key

factor in students' learning (Dunn, 1995). Prior knowledge, cognitive abilities and

motivation and learning styles play a central role in both face-to-face and online courses

(Graf, Liu & Kinshuk, 2010). By identifying student learning styles, teachers can consider making adjustments in their teaching strategies and their formal methods of assessment (Caine & Caine, 1991). Knowing students' learning styles helps instructors teach the entire class, but it also helps when working with students on an individual basis (Kanar, 1995). Researchers have shown that the accommodation of learning styles has resulted in significant learning gains for college students (Aragon et al., 2002; Dunn & Griggs, 2000; Dunn & Stevenson, 1997). In correlational studies, other researchers have shown the relationship between learning styles and achievement to be strong (Busato et al., 1998; Geisler-Brenstein, 1996; Matthews, 1996). Learning style has been viewed as a major factor in student academic achievement and satisfaction in online courses and should, therefore, influence the design of the course (Phipps & Merisotis, 1999).

Briggs (2000) discussed the need for educators to be aware of and adapt to individual learning styles of students. Ford and Chen (2001) have posited that individual learning style, along with instructional strategies, affects learning outcomes for students. Matching teaching and learning styles can result in positive student attitudes and a deeper understanding of the subject (Giles et al., 2006). Learning styles can also provide meaningful indicators of student success, because they provide information about different learning preferences (Akdemir & Koszalka, 2008; Zhang & Sternberg, 2009).

Students have different preferences in receiving, processing, and recalling information (Akdemir & Koszalka, 2008). An awareness of the process students use to learn information can potentially lead to better pedagogy to help with student understanding (Evans, Coolsc, & Charelsworth, 2010). Ideally, if most of the learning

styles are addressed, every student could be actively engaged in the lesson. Classroom practices that use learning styles can enhance students' learning, retention, and how new information is retrieved (Federico, 2000). Also, once students find courses that mesh with the ways they learn, changes in self-image, attitude, and possibly grades are potential outcomes (Krause, 1998). Dunn and Dunn (1993) stated that because students have a variety of different learning styles, uniform teaching practices would disallow students' success in the classroom. Even though results of studies have been contradictory, credit has been given to the importance of learning styles in the education process.

Considering learning style can be an important component in online curriculum design (Terrell, 2005). Palloff and Pratt (2003) suggested that, in the design of an online course, different learning styles should be incorporated to make the course more inclusive than exclusive for students. Further research needs to be conducted in regard to online education in mathematics. Findings in this study could lead to further refined research initiatives regarding learning style as a factor in online mathematics courses.

Russell (2001) observed that there was no significant difference in achievement results for online or face-to-face modalities. Still, the Department of Education (2009) reported that students enrolled in online courses produced slightly superior learning outcomes. Most of the online courses examined, however, were not mathematics classes. In the comparison of student achievement in online courses vs. face-to-face mathematics courses the results of research studies have been mixed. Some researchers have found learning style to be a significant variable in the study of online vs. face-to-face courses.

In others, however, no significant difference in mathematics achievement of students was identified. Boles, Pillay, and Raj (1999) stated

> Learning is a constructive, cognitive, and social process where the learner strategically manages the available cognitive, physical and social resources to construct knowledge. Such construction requires individuals to direct attention to relevant aspects of the given information, and to relate it to previous experiences and knowledge, that is, transform the information. Individuals access and process information differently, hence the success of any transformation process depends upon opportunities an individual has to access and process information in their preferred styles (p. 371).

With the continued growth of online education, it is vital to determine whether or not a student's learning style affects the academic achievement of the student in online vs. face-to-face education. Is it possible for students to be successful regardless of the mode of instruction or learning style? If students' likelihood for high achievement in online mathematics class could be estimated based on their learning styles, they could be either advised into the online environment or an appropriate alternative.

Dziuban and Moskal (2001) wrote that "a successful student majority in online courses reports a changed learning approach that relates to their learning styles" (p. 45). If it is determined that learning style traits have been instrumental in students' success in online mathematics courses, those traits might be appropriately taught to students at an early grade so they do not have to experience the frustration of adapting to the instructional differences that may occur in the online environment. Felder and Spurlin (2005) acknowledged the importance of the development of less preferred learning styles through training. Grasha (2002) stated that learning styles "can be changed and modified depending upon the classroom procedure used" (p. 171). For such shifts to occur,

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though, educators must implement extensive use of alternative teaching methods. An occasional use of classroom procedure does not seem to alter learning styles (Grasha, 2002). "Students have preferred styles of learning, some of which cross all fields and other that they favor in certain situations. Learning experiences can be tailored to your students' strength while including strategies that will help them strengthen their learning weaknesses" (Richlin, 2006, p. 12).

The aspects of using a social interaction learning styles inventory while researching an undergraduate online and face-to-face mathematics courses are missing from the current body of research. The literature closely related to this study only divided the students into two categories in terms of learning style (Matthews & Newman, 1994), compared different mathematics courses (Wetzel & Harmeyer, 1997), used a non-social learning style inventory when looking for significance to mathematics achievement (Bell, 1988; Clariana, 1997; Jai, 1994; Manochehri & Young, 2006; Smith, 1996), and only compared achievement between online and face-to-face mathematics courses (Esmaeili, 2001; Ryan, 2001; Weems, 2002). The particular learning styles of students has an impact on academic achievement in different academic areas (Corlett, 1993). This indicates that learning style research in different academic areas, e.g., mathematics, is to be a valuable addition to the existing body of research. Thus, it was imperative to research the potential benefits of online vs. face-to-face instruction for various content areas. This investigation was focused on the specific area of mathematics.

CHAPTER 3
METHODOLOGY

Introduction

This chapter contains an explanation of the methodology and procedures used to conduct the study. It contains a restatement of the purpose, an overview of the research design, and a rationale for the choice of methodology. The population, setting, and sample are described, and details are provided regarding the instrumentation used in the study. The processes and procedures used in the collection and analysis of the data are explained. Issues related to generalizability, validity, and reliability are also discussed.

Purpose of the Study

The purpose of this study was to determine if there is a significant relationship between learning styles and student learning outcomes in an online college mathematics course. In addition, the study was conducted to investigate the relationship of online learning and learning styles to student learning outcomes in the face-to-face environment.

Population and Setting

The population for this study was students who were enrolled in a private multimedia university located in the southeast. This university was selected for this study based on the high percentage of online undergraduate mathematics courses and the potential to add to the literature on learning styles as related to mathematics. The school is licensed by the Commission for Independent Education, the Florida Department of

Education, and is accredited by the Accrediting Commission of Career Schools and Colleges (ACCSC).

In 2011, the university had a population of approximately 8,600 students, of which approximately 73% were male. As to ethnicities, 54% were White, 19% were African American, 12% were Latin, 3% were Asian, 1% were Alaskan Native/American Indian and 11% were of a different ethnicity. The students' ages ranged as follows: 15-20 years of age, 20%; 21-26 years of age, 47%; 27-30 years of age, 14%; 31-35 years of age, 8%; 36-40 years of age, 5%; 41-45 years of age, 2%; 46-50 years of age 2%; and 51 and above 2%.

The university is known for its non-traditional programs, its learning environment, and the diversity of its students who come from around the world. To be admitted to the university, students must have completed a high school diploma or equivalent. The university does not use aptitude testing for admission.

The university supports an accelerated learning environment in which the average student takes one or two 4-week courses at a time. Students who pass the courses take new courses each month. Each course meets twice weekly and is comprised of four hours of lecture and four hours of laboratory. Students have to achieve a grade of 70% to pass each course. For face-to-face courses, students must attend 90% of all class meetings. Students failing either the attendance or grade component must retake the course. Approximately 40% of the student population is enrolled in programs that are completely online. Table 2 details the university's face-to-face, and online degree programs.

Table 2

Face-to-Face and Online University Programs

Programs	Face-to-Face	Online	Face-to-Face and Online
Associate's	Graphic Design, Recording Engineering		
Bachelor's	Digital Arts, Film, Game Development, Recording Arts, Show Production	Game Design, Graphic Design, Internet Marketing, Music Production	Computer Animation, Entertainment Business, Game Art, Music Business, Web Design and Development
Master's	Game Design	Creative Writing, Entertainment Business: Sports Management Elective Track, Education Media Design and Technology, Internet Marketing, Media Design	Entertainment Business
Graduate Certificate		Education Media Design and Technology, Internet Marketing	

<u>Sample</u>

The sample for this study was drawn from those students who are required to take a mathematics course entitled College Mathematics and Algebra (CMA). Students enrolled in the face-to-face programs of graphic design, recording arts, game art, digital arts and design, entertainment business, web design and development, show production, computer animation, and film are required to take CMA. Also students enrolled in online programs of entertainment business, Internet marketing, web design and development, computer animation, music business and graphic design are required to take CMA. Students can take courses online or face-to-face. On average, 200 students take CMA

face-to-face, and 300 students take CMA online each month. The face-to-face sections average 70 students per class, and the online sections average 25 students per section. The same curricula are used for online and face-to-face courses. Identical departmental PowerPoint slides are used in all lectures. Though teaching styles may vary among instructors in face-to-face sections, one standard examination is administered in all face-to-face and online sections. Regardless of mode of instruction or section of enrollment, students receive identical course content. The only exception is the online students have an assigned discussion posting due each week. This results in an experience across the online sections via the discussion postings and comments that vary from section to section. Identical materials and references are provided to all online and face-to-face students. Taking time and book use into consideration, there are differences in examinations between online and face-to-face students.

Students enrolled in the College Mathematics and Algebra (CMA) course were participants in the study. Students enrolled in the online degree program were the group deemed as online, and the students taking the course at the university campus were deemed face-to-face. The students do not have a choice as to whether they take courses online or face-to-face. It is strictly based on if their degree program is all online or all face-to-face.

Considering a reasonable bound of accuracy, the power for this study was set at a minimum of 30 students. A total of 432 students agreed to participate, 178 face-to-face and 254 online. There was a total of 12 instructors who taught the online courses and 5 instructors who taught the face-to-face courses.

The research design for the study was a quasi-experimental design. Because students were already enrolled in either an online or face-to-face course, a convenience sample was used. Students enrolled in the online class were considered as the experimental group, and students enrolled in the face-to-face class comprised the control group. Face-to-face students received instruction through lecture and laboratory. Online students received instruction via the online learning platform used by the University.

Academic performance was measured using questions from the National Assessment of Educational Progress (NAEP) Question Tool Database. The learning style of the students was measured using the Grasha-Reichmann Student Learning Styles Scales (GRSLSS) Inventory.

Research Questions and Hypotheses

1. Do learning styles have a predictive relationship with student achievement in an online college mathematics course?

    H_{01}: There is no significant relationship among the Grasha-Reichmann Student Learning Styles Scales (GRSLSS) Inventory and student achievement in an online college mathematics course.

2. Do the various learning styles among mathematics students in online versus face-to-face courses predict mathematics achievement?

H_{02}: There is no significant relationship among various learning styles among mathematics students in online and face-to-face courses and mathematics achievement.

<p style="text-align:center"><u>Instrumentation</u></p>

Three instruments were used as measures in the study. Prior mathematical knowledge was measured by an initial assessment. The software that was used for this assessment is called ALEKS, which stands for Assessment and Learning in Knowledge Spaces®. It is an artificially intelligent web-based learning system. It uses adaptive questioning to determine what students do and do not know. Students' academic performance was measured using questions from the NAEP Question Tool Database. Students' learning styles were measured using the Grasha-Reichmann Student Learning Styles Scales (GRSLSS) Inventory. Detailed explanations of the instruments are presented in the following sections. Information related to instrument development, measures, content, disposition and validity are provided. Studies that include normative data relevant to this study are also discussed.

<p style="text-align:center">National Assessment of Educational Progress (NAEP) Question Tool Database</p>

The National Assessment of Educational Progress (NAEP), sponsored by the Department of Education, informs the public of academic achievement of elementary and secondary students in the United States by producing the Nation's Report Card (U. S. Department of Education, 2009). The National Center for Educational Statistics (NCES)

<p style="text-align:center">65</p>

develops, analyzes, and reports the test questions. The first NAEP assessment was administered in 1969 and the findings have been a vital part of America's evaluation of the state and progress of education (U.S. Department of Education, 2011). The mathematics assessment has been validated as sufficient in supporting the conclusions made from the assessment (Daro, Stancavage, Ortega, DeStefano, & Linn, 2007). The questions used to determine mathematics achievement in this study were selected from the NAEP Question Tool database which was comprised of 2,000 questions from past NAEP assessments in nine subject areas. This database allows for questions to be searched and used based on characteristics such as subject and grade. The test was comprised of 20 questions covering content that was part of the CMA curriculum. These questions were selected after careful examination of the NAEP database questions. The best-fit questions, according to the objectives of CMA, were chosen. The assessment was administered to participating students only after all material on the assessment had been presented in the CMA course. Students' mathematics achievement was represented by a score ranging from 0 to 20 as dictated by the number of correct answers on the assessment.

The NAEP has been used to conduct studies on mathematics achievement since 1973. This long time span has allowed for growth and modifications as to the types of questions asked on the assessments. The Nation's Report Card has been published for fourth- and eighth-grade mathematics achievement based on this assessment. An assessment for 12th grade is being produced as well. For the 2009 Report Card, approximately 300,000 students were assessed in fourth- and eighth-grade mathematics

courses. This report has led to major changes in mathematics education in the United

States. One of the most referenced reports, A Nation at Risk (1983), involved data

collected from NAEP for core subjects and evoked awareness of deficiencies of

American students in areas such as mathematics. The course outcomes for the

mathematics course used in this research were integers, decimals, percents, fractions,

geometry, measurements, variables, exponents, equations, inequalities, graphing, word

problems, business applications, statistics, and probabilities. Thus, the NAEP database

was determined to be appropriate for this study as it addressed all the assessed areas and

enabled a quality comparison.

Grasha-Reichmann Student Learning Styles Scales

Different factors played a part in the selection of the instrument used for

determining learning styles of students. These factors include the potential use of the

data, the design and validity of the instrument, and the type of test administration (James

& Gardner, 1995). Taking into account these factors, the best learning styles instrument

for this study was determined to be the Grasha-Reichmann Student Learning Styles

Scales (GRSLSS) Inventory.

The GRSLSS Inventory (Grasha, 1996; Hruska-Riechmann & Grasha 1982) has

been used in various studies to determine students' learning styles. It was used in the

present research based on the following four reasons. First, it was designed to be used

with senior high school and college students (Hruska-Riechmann & Grasha, 1982).

Second, it is unique in design, because it is one of the few learning style instruments that

addresses the impact of social interaction on a learning style. It takes into account how a student interacts with other students, the instructor, and with the learning process. Because online courses do not have the same interaction as face-to-face classes, this is an important factor to observe. Third, the GRSLSS Inventory uses six categories to determine a students' learning style. Each category produces a score for that particular student. Students possess some of each of the learning styles described by the GRSLSS Inventory. Fourth, the instrument can be used for the design of the course as students' needs are taken into consideration (Diaz & Cartnal, 1999). The instrument is comprised of 60 questions which can be administered on paper or online. Students participating in the present study took the online version of the test, as it is the easiest format to be administered for a course that is online and face-to-face.

The questions in the GRSLSS pertain to attitudes and feelings toward past courses based on a 5-point Likert-type scale ranging from 1 = strongly disagree to 5 = strongly agree. After the test is completed, a score between 1 and 5 is given for each of the following categories: (a) independent, (b) dependent, (c) competitive, (d) collaborative, (e) avoidant, and (f) participative. Depending on the score, a student is marked low, moderate, or high for each category. The theory behind this instrument is that each student will have a blend of characteristics from the different categories, but most students will have one or two dominant preferences. For this study, the category with the highest ranking will be determined as the learning style for each student. Brief descriptions of the GRSLSS Inventory categories follow:

1. Independent categorizes students who prefer self-paced instruction, study independently and work alone on course projects.

2. Dependent categorizes students who prefer guidance, structure and an authoritative figure that tells them what to do.

3. Competitive categorizes students who learn to be noticed for their academic accomplishments and the want to perform better than their classmates.

4. Collaborative categorizes students who learn best by sharing and attaining information from peers and teachers in small-group discussion and projects.

5. Avoidant categorizes students who are not excited about attending class and are not interested in the material being taught. They are sometime very overwhelmed by class activities.

6. Participative categorizes students who want to meet the teacher's expectations by doing as much work as possible and are interested in class activities and discussions.

Several studies have been conducted on the use of the GRSLSS Inventory to determine learning styles for students. One study by Andrews (1981) was conducted to investigate how teaching methods and student learning styles influence academic achievement. The results showed that when students' social-emotional needs were met, students achieved at higher levels. In a later study, Andrews (1984) showed that two learning styles of dependent and independent students performed differently based on differing teaching methods of either discovery learning or expository learning. In 2000, McColgin concentrated dissertation research on learning styles of nursing students and

found no statistically significant predictor of academic performance. Diaz and Cartnal (1999) also used the GRLSS to show the learning styles of online students compared to face-to-face students. Their findings were similar to those of Andrews (1984). There was a significant difference between the achievement of independent versus dependent learning styles of online students compared to face-to-face students. Diaz and Cartnal concluded that face-to-face students were more dependent, and online students were more independent. These studies showed varied use of the GRSLSS in face-to-face courses. As discussed in the literature review, studies have been conducted using the GRSLSS Inventory to measure the learning style of online students. However, no studies have focused on academic achievement in mathematics as it relates to learning style.

Data Collection Procedures and Variables

This research was initiated only after the approval of the Institutional Review Board of the University of Central Florida was obtained (Appendix A). The following steps were taken in the data collection process for this study:

1. Data were collected during October of 2011. The GRSLSS Inventory was used as the learning style survey and the mathematics achievement test were included in both face-to-face and online course curricula. The mathematics achievement score was the questions from the NAEP database.

2. The first assignment that the students in both the online and face-to-face course completed was the instrument used to collect initial assessment of their current mathematics knowledge. This initial assessment, given through

ALEKS, was used as each student's baseline for their mathematical content knowledge prior to the course. The assessment was computer-based and used adaptive questioning.

3. During the first week of class, all participants completed the online Grasha-Reichmann Student Learning Styles Scales (GRSLSS) Inventory (Appendix C). The survey was administered using an online platform. The student responses were stored in a database, and the researcher received the identity of students only through an identification number to protect the confidentiality of the student. This identification number was created to enable a comparison of achievement scores.

4. At the same time participants took the learning style assessment through an online database, they also responded to a demographic questionnaire indicating their age, gender, program of study, ethnicity, and if they were taking the class online or face-to-face (Appendix D). The face-to-face and online sections were separated for comparative purposes. Demographic data were used for descriptive purposes.

5. During the fourth week of the course, all participants completed the 20 questions selected from the NAEP Question Tool database through an online database (Appendix B). The score from 0 to 20 provided an assessment of participants' academic performance.

6. All course instructors with participating students completed a brief questionnaire providing demographic data such as age, gender, years of

teaching experience, and years of teaching CMA. This information was used

for descriptive purposes.

The information for this study was acquired during the Fall of 2011. The

electronic data that were collected were downloaded and saved to an external hard drive

that was locked in a secure cabinet during the times they were not used for statistical

analyses.

Data Analysis

The first research question was used to investigate a prediction between learning

styles and student achievement in an online college mathematics course. The second

question addressed the predictive strength of various learning styles among mathematics

students in online and face-to-face courses on mathematics achievement.

A full regression model was used to determine if student mathematics

achievement could be predicted from a combination of learning styles and course

delivery method. The data collected from NAEP served as the dependent variable, and

individual learning styles and course delivery method were the independent variables. A

hierarchical linear regression was run in three blocks. The first block contained an initial

assessment score which was intended to serve as a control variable for the model. The

second block contained all the learning styles as predictors. These variables were

presented as binary indicators rather than as actual scores in order to utilize one particular

dominant learning style, rather than scores on each separate learning style. The third

block added the variable of class type. The hierarchical regression was accomplished by

adding the one predictor of course delivery method while holding prior achievement and learning styles constant. The results indicated if course mode served as a predictor of performance. In addition, the relationships between the collected demographics were analyzed. In summary, each research question required regression analysis procedures which yielded the results of this research.

<div align="center">Limitations</div>

There were limitations associated with this study. Each limitation was taken into consideration when interpreting the results.

Students may have had different levels of technological familiarity. This could cause a difference in their achievement scores for technological reasons. Also, students with certain learning styles may have been more inclined to participate in research projects than other students with other learning styles.

The quality of instruction was also considered to be a potential limitation in the study. The course had objectives to be met by the students, but the delivery of the content by instructors can be a potential limitation. Instructor quality, feedback and coherence, which may have nothing to do with learning style, can impact student learning.

CHAPTER 4
ANALYSIS OF THE DATA

Introduction

The purpose of this study was to determine if there was a significant relationship between learning styles and student learning outcomes in an online college mathematics course. In addition, the relationship of learning styles to student learning outcomes in the online versus the face-to-face environment was investigated.

This chapter contains the results of the analysis of the data in this study. Demographics are presented for the participants followed by a rationale for the analysis, a description of the procedures, and the results of the analysis for each of the two research questions which were used to guide this study.

Demographic Description of Participants and Instructors

The study took place at a private university located in the southeast region of the United States. Because students were already enrolled in either an online or face-to-face course, a convenience sample was used. A total of 779 students participated in the study. Students enrolled in the online class were considered as the experimental group, and students enrolled in the face-to-face class comprised the control group. A total of 278 students were enrolled in face-to-face courses, and 501 students were enrolled in online courses. The two groups were given a learning styles inventory survey and an initial assessment at the beginning of the course. At the conclusion of the course, a mathematics test to gauge student achievement was administered.

Additional demographic data regarding participants is displayed in Table 3. Of the participants, 42% were under 21 years of age, and 58% were 21 and over. Ethnicity was split into three groups: White, Black, and Other. A total of 41% were White, 39% were Black, and 20% were Other. In regard to gender, 61% were Male and 39% were female. Overall, 37% of the participants were in the face-to-face modality and 63% were in the online modality.

Ten instructors taught the course used for this study. Years in teaching ranged from 6 to 16 years with the average being 10 years. Ranges of ages were from 29 to 64 years old. A total of 60% were male and 40% were female. As to ethnicity, 60% were White, 20% were Black, and 20% were Hispanic. The course was comprised of four 70-student, face-to-face sections and 34, online sections, each with 25 students. Each of the four instructors teaching face-to-face classes also had two or three online courses. The rest of the online sections were split between the remaining six instructors. Instructors who taught only online courses had three or four sections.

Table 3

Demographic Characteristics: All Students (N = 779)

Characteristic	Percentage
Modality	
Online	37%
Face-to-face	63%
Age	
Under 21	42%
21 and over	58%
Gender	
Male	61%
Female	39%
Ethnicity	
White	41%
Black	39%
Other	20%

Data Analysis for Research Question 1

Research Question 1: Do learning styles have a predictive relationship with student achievement in an online college mathematics course?

A hierarchical linear regression was used to address this question to control for prior mathematical knowledge. This procedure addressed the predictive relationship of learning styles on student achievement while controlling for students' prior mathematics knowledge.

Student achievement served as the dependent variable. It consisted of the data students received on the final, post-test mathematics assessment. One independent variable was the initial mathematics assessment. This score served as the first block of

the model. Predominant student learning style, as defined by the Grasha-Riechmann Student Learning Styles Scales (GRSLSS), served as the other independent variable.

Based on the results of the GRSLSS, students were categorized as one of six learning styles: independent, avoidant, collaborative, dependent, competitive, or participatory, according to the highest score received. Fewer than 10 (0.01%) students from the entire sample were avoidant or competitive. The next most populated category was dependent, which was comprised of 84 (11%) students, a much greater number. Therefore, the two lowest-populated categories were removed for modeling purposes. Dummy variables were used to represent the independent, collaborative, and dependent categories. When all the other categories were set to zero, participatory was represented. All of the dummy variables representing the independent variable for learning style were entered into individual blocks of the model. Statistical assumptions regarding multicollinearity, normality, outliers, linearity, independence, and homogeneity of variance were checked prior to analyzing the model. Because two different independent variables were used, it was important that they did not explain too much of the same variance in the dependent variable. The condition index was referenced to determine the extent of multicollinearity. It was important that these values be less than 15. Because the highest condition index was 5.75, lack of multicollinearity was assumed.

In regard to normality, the skewness and kurtosis were checked for both standardized and unstandardized residuals of the model. In regard to both the unstandardized and standard residuals, the skewness was -.61 and the kurtosis was .35. Both the skewness and kurtosis were within the expected range of -2 and 2. Histograms,

Q-Q plots, and boxplots did not indicate non-normality; thus, normality of the distribution was assumed.

Outliers can present a problem in a regression analysis because influential points can greatly change the way the line fits with the rest of the data. Therefore, it was important to check for outliers. Cook's distances were 0.04, below the maximum recommended value of 1. The centered leverage values were all also below the maximum recommended value of 0.2, landing at 0.04. When the histogram of residual values were examined, a small number of points could be seen as potential outliers, but their non-extreme nature led to the overall conclusion that outliers were not an apparent issue.

When checking for linearity, independence, and homogeneity of variance, assumptions were met. The purpose of the linearity check was to determine if the data were appropriate for fitting with a straight-line model. The standardized residuals versus both the predicted values and the independent variable were largely within -2 and 2. Independence ensures that the data are not apparently collected in any particular sequence which would have implications that one observation was dependent upon the results of the previous one. This assumption was met because there was no major indication of the spread decreasing or increasing when plotting the standardized residuals versus the predicted value and the independent variables. Also, when analyzing these plots, no particular patterns arose, and the spread was generally even throughout. Thus, homogeneity of variance was assumed.

After finding the assumptions to be met, the model was built in two blocks. The results are displayed in Table 4. Block 1 was considered to be the base model where only initial assessment score was entered. The block indicated that the initial assessment score significantly predicted current score: $F(1, 422) = 133.08$, $p < .001$. Additionally, a substantial amount of variability in current score, 24%, was explained by initial assessment score: $R^2 = .24$.

In the second block, indicator variables for learning style were entered. When controlling for prior achievement, these indicator variables did not yield a significant addition: $\Delta F(3, 419) = 0.20$, $p = .89$. No additional variability in current score, 0.1%, was explained by this block of variables: $\Delta R^2 = .001$.

The results from this model-building exercise indicated that predominant learning style had no apparent influence on mathematics achievement. The final model is Current achievement $= 61.04 + 0.40$(Prior Score) $- 0.82$(Independent) -1.21(Collaborative) $- 0.68$(Dependent) displayed in below. Prior score is represented by the continuous score variable. The three learning style indicators (independent, collaborative, and dependent) are dummy variables that hold a value of either 0 or 1.

Table 4

Summary of Hierarchical Regression Analysis for Learning Styles Predicting Mathematics Achievement, Total Population (N = 424)

Variable	Block 1			Block 2		
	B	*SE B*	B	*B*	*SE B*	β
Constant	60.44	1.51		61.04	1.75	
Initial Assessment	0.40	0.04	.49**	0.40	0.04	.49**
Learning Style						
Independent				-0.82	1.64	-.02
Collaborative				-1.21	1.62	-.04
Dependent				-0.68	2.10	-.02
R^2		.24			.24	
ΔF		133.08**			0.20	

*$p < .05$. **$p < .01$.

Data Analysis for Research Question 2

Research Question 2: Do the various learning styles among mathematics students in online versus face-to-face courses predict mathematics achievement?

Two hierarchical linear regressions were run to address this question, one linear regression for online and one for face-to-face modalities. This method allows for the relationship of learning styles on student achievement to be predicted while controlling for students' prior mathematics knowledge. Separate models were used to differentiate whether learning styles were a significant predictor of mathematics achievement for online, face-to-face, both, or neither of the modalities. The dependent and independent

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variables used for these analyses were identical to those used in Research Question 1. Student achievement served as the dependent variable. Initial assessment and predominant learning style served as independent variables.

Data on multicollinearity, normality, outliers, linearity, independence, and homogeneity of variance were acquired to check for assumptions. In regard to the face-to-face group, there was evidence of a normality violation, as the kurtosis was 4.3. Therefore, three data points with extreme standardized residuals, far beyond the reasonable limit of -3, were removed. A similar situation was present for the model reflecting the online group. In this case, the kurtosis values for the standardized and unstandardized residuals were between 3.77 and 4. One extreme residual with a value beyond -5 was subsequently removed. Regarding multicollinearity, 6.28 was the highest condition index for the face-to-face students, and 2.93 was the highest condition index for online students. Hence, lack of multicollinearity was assumed for both the face-to-face and online models.

After the removal of the extreme point, evidence of normality was examined. For the face-to-face model, the unstandardized residual skewness was -0.83, and the kurtosis was 0.87. Both were within the expected range of -2 and 2 and had similar values for the standardized residuals. For the online model, indicators were also within the expected range of -2 and 2, with unstandardized residual skewness of -0.68, kurtosis of 0.78, and near identical values for the standardized residuals. No additional indicators of non-normality were shown in histograms, Q-Q plots, or boxplots. Thus, normality of the distribution was assumed.

The outliers for both face-to-face and online modalities were not an apparent issue. The maximum Cook's distances for online students was 0.07, well below the maximum of 1. The centered leverage values were all below the maximum of 0.2 with the highest being 0.08. For the online group, Cook's maximum distance was 0.07 and the centered leverage value maximum distance was 0.06. Histograms for both the face-to-face and online modalities uncovered a handful of points visually identified as outliers. Because they were not extreme in nature, they were retained.

The assumption of linearity was met for both face-to-face and online courses. With few exceptions, the standardized residuals versus the predicted values for both face-to-face and online were generally within -2 and 2. The standardized residuals versus the independent variables were also plotted and yielded values that were between -2 and 2. Due to the binary nature of some of the independent variables, randomness was somewhat difficult to discern, but there was no startling pattern that was made apparent.

Both independence of the distribution and homogeneity of variance conditions were assumed. When plotting the standardized residuals versus the predicted value and the independent variables, respectively, there was no major indication of spread increasing or decreasing for both the face-to-face and online models. In plotting the standardized residuals versus the predicted value, no patterns were found. There was a generally even spread throughout. This finding was true for both the face-to-face and online models.

The model addressing the face-to-face modality was developed first, with results located in Table 5. The first block, representing the base model, contained the initial

assessment score as the only independent variable. This iteration of the block uncovered that the initial assessment was a significant predictor of current score: $F(1, 176) = 47.22$, $p < .001$. Additionally, a substantial amount of variability in current score, 21.2%, was explained by the initial assessment score: $R^2 = .212$.

Table 5

Summary of Hierarchical Regression Analysis for Learning Styles Predicting Mathematics Achievement, Face-to-Face Only (N = 178)

Variable	Block 1			Block 2		
	B	*SE B*	B	*B*	*SE B*	β
Constant	54.21	2.73		54.46	3.02	
Initial Assessment	0.51	0.08	.46**	0.51	0.08	.46**
Learning Style						
Independent				-0.74	2.78	-.02
Collaborative				0.26	2.65	.01
Dependent				-0.70	3.09	-.02
R^2		.21			.21	
ΔF		47.22**			0.05	

*$p < .05$. **$p < .01$.

The dummy variables representing predominant learning style were entered as indicator variables in the second block. When controlling for prior achievement, this block of variables did not yield a significant addition to the model: $\Delta F(3, 173) = 0.05$, $p =$

.98. In terms of practical significance, no additional variability in current score, 0.1%, was explained by this block of variables: $\Delta R^2 = .001$. The results of this model-building exercise indicated that predominant learning style had no apparent influence on mathematics achievement for face-to-face students. The final model is Current achievement = 54.46 + 0.51(Prior Score) − 0.74(Independent) + 0.26(Collaborative) − 0.70(Dependent).

The model addressing the online modality was subsequently created. The results are displayed in Table 6. The first block, representing the base model, contained the initial assessment score as the only independent variable. This iteration of the model uncovered that the initial assessment score was a significant predictor of current score: $F(1, 252) = 66.59$, $p < .001$. Additionally, a substantial amount of variability in current score, 20.9%, was explained by the initial assessment score: $R^2 = .209$.

The dummy variables representing predominant learning style were entered as indicator variables in the second block. When controlling for prior achievement, this block of variables did not yield a significant addition to the model: $\Delta F(3, 249) = 0.45$, $p = .72$. In terms of practical significance, no additional variability in current score, 0.4%, was explained by this block of variables: $\Delta R^2 = .004$.

The results of this model-building exercise indicated that predominant learning style had no apparent influence on mathematics achievement for online students. The final model is Current achievement = 65.21 + 0.33(Prior Score) − 0.48(Independent) − 1.89(Collaborative) + 1.23(Dependent).

Table 6

Summary of Hierarchical Regression Analysis for Learning Styles Predicting Mathematics Achievement, Online Only (N = 254)

	Block 1			Block 2		
Variable	*B*	*SE B*	B	*B*	*SE B*	β
Constant	64.73	1.95		65.21	2.27	
Initial Assessment	0.33	0.04	.46**	0.33	0.04	.46**
Learning Style						
Independent				-0.48	2.03	-.02
Collaborative				-1.89	2.06	-.06
Dependent				1.23	2.93	.03
R^2		.21			.21	
ΔF		66.59**			0.45	

*p < .05. **p < .01.

Data Analysis: Mathematics Performance by Learning Styles and Gender

Additional demographic analyses were performed to determine whether there was a difference in mathematics performance in terms of learning styles and gender. Two chi-square tests of independence were run to determine the presence of a relationship between mathematics performance (high and low) and predominant learning style, as well as between mathematics performance (high and low) and gender. High/low mathematics performance was dictated by the median of all mathematics scores. This median was 75. Thus, those students who scored 75 or greater were considered high-performing; those below 75 were low-performing.

The test, $\chi^2(3) = 1.51$, $p = .68$, indicated that there was no significant relationship between mathematics performance and predominant learning style. There was also no practical significance in this relationship; Cramer's $v = .06$. All standardized residuals (a standardized difference between observed and theoretically expected values) were well within -2 and 2, further cementing the lack of relationship. Results are shown in Table 7.

Table 7

Chi-Square Analysis for Mathematics Test Performance and Predominant Learning Style (N = 439)

Test Performance	Independent	Collaborative	Dependent	Participatory
High				
Frequency	39	44	22	59
Percentage	23.8	26.8	13.4	36.0
Standard Residual	0.1	0.5	0.5	-0.7
Low				
Frequency	64	66	31	114
Percentage	23.3	24.0	11.3	41.5
Standard Residual	-0.1	-0.4	-0.4	0.5

Note. $\chi^2 = 1.51$, $df = 3$, $p = .68$, $v = .06$.

The test, $\chi^2(1) = 0.51$, $p = .49$, indicated that there was no significant relationship between mathematics performance and gender. There was also no practical significance in this relationship; $\varphi = .03$. All standardized residuals (a standardized difference between observed and theoretically expected values) were well within -2 and 2, further cementing the lack of relationship. Results are displayed in Table 8.

Table 8

Chi-Square Analysis for Mathematics Test Performance and Gender (N = 448)

Performance	Male	Female
High		
Frequency	124	43
Percentage	74.3%	25.7%
Standard Residual	-0.3	0.5
Low		
Frequency	217	64
Percentage	77.2%	22.8%
Standard Residual	0.2	-0.4

Note. $\chi^2 = 0.51$, $df = 1$, $p = .49$, $\phi = .03$.

Data Analysis: Performance, Ethnicity, Sex, Age, and Degree Program

Additional demographic analyses were run to determine whether there was a difference in test scores between students of different demographic groups and within different course modalities when controlling for prior performance. A series of ANCOVA tests were run to check for the presence of an interaction between a given demographic and a course modality when describing differences between student test scores. The dependent variable was the final mathematics test score. The covariate was the initial mathematics score. The two independent variables were modality of the course and the specific demographic variable in question. The demographics that were analyzed were ethnicity, gender, age, and degree program.

All assumptions for the ANCOVA tests were met. Prior to running the tests, the basic makeup of the dependent variable, final mathematics test score, was checked.

Based on a boxplot, the handful of outliers were not extreme in nature, and the variable did not show any extreme degree of skewness (-1.09) or kurtosis (1.79). Both had values that fell within the normal range of -2 and 2. Additionally, it is highly desirable that there is no risk of multicollinearity, or significant interaction between each independent variable and the covariate. For each of the ethnicity, gender, and age variables and modality, no interaction with the covariate was statistically significant ($p > .05$ for all tests). However, there was a significant difference in course performance in the area of academic program.

<div align="center">Ethnicity</div>

The first demographic examined was ethnicity, and participants were divided into the categories of White, Black, and Other. Two particular results were focused on in this ANCOVA. First, any differences in performance by ethnicity were examined. Subsequently, any differences in performance, when looking at the interaction between ethnicity and course modality, were examined.

In regard to ethnicity alone, there was no significant difference in course performance, $F(2, 430) = 2.51$, $p = .08$, when examining differences in mathematics test performance by ethnicity while controlling for initial assessment performance. Additionally, there was no practical significance in this relationship, partial $\eta^2 = .012$, which implies that only 1.2% of the variation in test performance could be accounted for by ethnicity alone. All in all, there were slight differences in performance, but they were not significant. Descriptive statistics are provided in Table 9.

Table 9

Descriptives for Scores by Ethnicity: All Students (N = 437)

Ethnicity	*M*	*SE*	n
White	76.42	1.12	184
Black	72.81	1.22	160
Other	75.91	1.53	93

Note. Controlled for initial assessment score at a value of 39.92.

When examining differences in mathematics test performance by the interaction between ethnicity and modality while controlling for initial assessment performance, there was no significant difference in course performance, $F(2, 430) = 0.76$, $p = .47$. Additionally, there was no practical significance in this relationship, partial $\eta^2 = .004$, which implies that only 0.4% of the variation in test performance could be accounted for by the interaction between ethnicity and course modality. Descriptive statistics are provided in Table 10.

The same patterns were generally followed for means in the interaction analysis within both modality groups as were followed for ethnicity alone. The only exception involved Other ethnicity students outscoring White students in the face-to-face group. Online students outscored face-to-face students. No significant interactions between ethnicity and modality were found.

Table 10

Descriptives for Scores by Ethnicity: Modality Combination Groups

Ethnicity	Face-to-Face (n = 181)			Online (n = 256)		
	M	*SE*	n	*M*	*SE*	n
White	72.77	1.72	73	80.07	1.46	111
Black	70.65	1.90	64	74.96	1.51	96
Other	74.37	2.22	44	77.45	2.11	49

Note. Controlled for initial assessment score at a value of 39.92.

Gender

The next demographic examined was gender. When observing gender, participants were divided into the categories of male and female. Two particular results were focused on in this ANCOVA. First, any differences in performance by gender were examined. Any differences in performance, when looking at the interaction between gender and course modality, were subsequently examined.

When analyzing differences in mathematics test performance by gender alone when controlling for initial assessment performance, no significant difference in course performance was revealed, $F(1, 432) = 0.03$, $p = .87$. Additionally, there was no practical significance in this relationship, partial $\eta^2 < .001$, which implies that no variation in test performance could be accounted for by gender alone. Overall, male and female students scored practically identically on the mathematics assessment. Descriptive statistics are provided in Table 11.

Table 11

Descriptives for Scores by Gender

	All Students ($n = 437$)		
Gender	*M*	*SE*	n
Male	75.50	0.80	331
Female	75.20	1.56	106

Note. Controlled for initial assessment score at a value of 39.92.

There was a significant difference in course performance, $F(1, 432) = 11.85$, $p = .001$, when examining differences in mathematics test performance by the interaction between gender and modality while controlling for initial assessment performance. Additionally, there was a small amount of practical significance in this relationship, partial $\eta^2 = .027$, which implies that 2.7% of the variation in test performance could be accounted for by the interaction between gender and course modality.

Descriptive statistics for the interaction effect are displayed in Table 12. The significant interaction was caused by the fact that in the face-to-face courses, females greatly outperformed male students. However, in the case of the online courses, male students outperformed female students. Differences in patterns led to the significant interaction.

Table 12

Descriptives for Scores by Gender: Modality Combination Groups

Gender	Face-to-Face ($n = 181$)			Online ($n = 256$)		
	M	*SE*	n	*M*	*SE*	n
Male	71.63	1.20	150	79.36	1.10	181
Female	77.36	2.64	31	73.04	1.69	75

Note. Controlled for initial assessment score at a value of 39.92.

Age

The third demographic examined was student age. When considering age for analytical purposes, participants were divided into the categories of under 21 and 21 and over. As with the other analyses, two particular results were focused on in this ANCOVA. First, any differences in performance by age group were examined. Any differences in performance, when looking at the interaction between age group and course modality, were subsequently examined.

There was no significant difference in course performance, $F(1, 432) = 2.46$, $p = .12$, when examining differences in mathematics test performance by age group alone when controlling for initial assessment performance. Additionally, there was no practical significance in this relationship, partial $\eta^2 = .006$, which implies that only 0.6% of the variation in test performance could be accounted for by age group alone. Descriptive statistics are located in Table 13. Overall, students who were under 21 scored higher than students aged 21 and over, but differences were not significant.

Table 13

Descriptives for Scores by Age

| | All Students (*n* = 437) | | |
Age	*M*	*SE*	n
Under 21	75.80	1.09	206
21 and Over	73.20	1.23	231

Note. Controlled for initial assessment score at a value of 39.92.

Additionally, there was no significant difference in course performance, $F(1, 432)$ = 1.77, p = .18, when examining differences in mathematics test performance by the interaction between age group and modality while controlling for initial assessment performance. Aside from the lack of statistical significance, there was no practical significance in this relationship, partial η^2 = .004. This implies that only 0.4% of the variation in test performance could be accounted for by the interaction between age group and course modality. Descriptive statistics for the interaction effect are provided in Table 14.

The same patterns were generally followed as in the case of age group alone. The students in the under 21 group outperformed students in the 21 and over group within both the face-to-face and online groups, although both groups performed nearly identically within the online segment. These similarities in patterns between the two groups led to a lack of significant interaction.

Table 14

Descriptives for Scores by Age: Modality Combination Groups

Age	Face-to-Face (*n* = 181)			Online (*n* = 256)		
	M	*SE*	n	*M*	*SE*	n
Under 21	73.75	1.28	136	77.85	1.81	70
21 and Over	68.98	2.22	45	77.43	1.08	186

Note. Controlled for initial assessment score at a value of 39.92

Degree Program

The fourth analysis addressed differences by degree program. Participants were divided into the categories of Entertainment and Music Business & Production; Recording Arts & Engineering; Games, Graphics, & Computers; and Film for this particular analysis. Entertainment and Music Business & Production consists of the programs of Entertainment Business, Music Business, Music Production and Show Production. Recording Arts & Engineering consists of the programs of Recording Arts and Recording Engineering. Games, Graphics, & Computers consists of the following programs: Computer Animation, Digital Arts, Game Art, Game Design, Game Development, Graphic Design, Internet Marketing, and Web Design & Development. The Film category does not have any other programs with which it is associated.

Two particular results were focused on in this ANCOVA. First, any differences in performance by academic program were examined. Any differences in performance

when looking at the interaction between academic program and course modality were subsequently examined.

There was a significant difference in course performance, $F(3, 412) = 0.42$, $p = .074$, when examining differences in mathematics test performance by academic program alone while controlling for initial assessment performance. Additionally, there was a small amount of practical significance in this relationship, partial $\eta^2 = .023$, which implies that 2.3% of the variation in test performance could be accounted for by academic program alone. According to pairwise post-hoc tests, Film students scored significantly higher than did those in the Entertainment and Recording Arts groups, respectively. The rest of the groups did not differ significantly from one another. Descriptive statistics are located in Table 15.

Table 15

Descriptives for Scores by Academic Groups

	All Students ($n = 421$)		
Academic Group	*M*	*SE*	n
Entertainment and Music Business & Production	72.17	1.89	150
Recording Arts & Engineering	73.66	1.60	116
Games, Graphics, & Computers	76.29	1.65	88
Film	79.88	1.92	67

Note. Controlled for initial assessment score at a value of 39.69.

There was no significant difference in course performance, $F(3, 412) = 0.42$, $p =$ .74, when examining differences in mathematics test performance by the interaction between academic program and modality while controlling for initial assessment performance. Additionally, there was no practical significance in this relationship, partial $\eta^2 = .003$, which implies that only 0.3% of the variation in test performance could be accounted for by the interaction between academic program and course modality. Descriptive statistics are located in Table 16.

Table 16

Descriptives for Scores by Academic Group: Modality Combination Groups

Academic Group	Face-to-Face ($n = 180$)			Online ($n = 241$)		
	M	*SE*	n	*M*	*SE*	n
Entertainment and Music Business & Production	67.83	3.57	17	76.50	1.27	133
Recording Arts & Engineering	69.80	1.59	88	77.53	2.84	28
Games, Graphics, & Computers	73.79	2.70	30	78.79	1.94	58
Film	78.09	2.19	45	81.68	3.17	22

Note. Controlled for initial assessment score at a value of 39.69.

The same patterns were generally followed as in the case of academic group alone, wherein students in the Film program outperformed students in the other programs.

Entertainment had the lowest performance followed by Recording Arts, followed by

Games. This parallel pattern led to a lack of significant interaction between modality and

academic program.

<div align="center">Summary of Findings</div>

The data revealed a series of interesting points when dealing with learning style

and achievement. The first research question addressed the predictive relationship of

learning styles on student achievement while controlling for students' prior mathematics

knowledge, through the use of a hierarchical linear regression. The initial assessment

score significantly predicted current score, but predominant learning style had no

apparent influence on mathematics achievement.

The second research question queried the predictive relationship of learning styles

on student achievement while controlling students' prior mathematics knowledge for both

face-to-face and online modalities. Two hierarchical linear regressions were run to

address this question, one for online and one for face-to-face. Similar to the findings for

Research Question 1, prior score significantly predicted current score, but predominant

learning style had no apparent influence on mathematics achievement for either face-to-

face or online students.

Although outside the direct scope of the research questions, a series of ANCOVA

tests were run to examine the presence of any relationships between a given demographic

and course modality when describing differences between student test scores while

controlling for prior academic performance. The demographics of interest included

ethnicity, gender, age, and academic program. When examining demographics alone without respect to modality, there was no significance in course performance between students in various ethnicity, gender, or age groups. However, there was a significant difference in course performance in the area of academic program, as Film students scored significantly higher than those in the Entertainment and Recording Arts groups.

When examining the interaction effect between demographics and course modality while controlling for initial assessment performance in explaining post-test performance, there were no significant differences in the cases of ethnicity, age, or academic program. However, there was a significant difference in the case of gender, where females outperformed males in the face-to-face setting. However, the reverse trend occurred in the online setting. For the remainder of the variables, patterns existed, but because they were consistent between modalities, no significant interactions were indicated.

When considering other items besides significance, some themes were apparent. Online students outscored face-to-face students. Neither model indicated that learning styles had a significant effect on mathematics achievement when controlling for prior achievement. In regard to learning style comparisons, independent learners indicated lower scores compared to participatory learners. Collaborative learners showed higher scores compared to participatory learners among face-to-face students, but lower scores among online students. Dependent learners showed lower scores compared to participatory learners among face-to-face students, but higher scores among online students. In terms of ethnicity, Other ethnicity students outscored White students within

the face-to-face group. In all other cases, White students scored higher. Addressing

gender, male and female student scores were practically identical on the mathematical

assessment.

CHAPTER 5
RESULTS

"In a society where individuals matter, where business is often based on individual initiative and creativity, where the cry is 'no child is left behind', understanding and addressing learning differences is of central importance" (Newman-Rozenfeld, 2008, p. 2).

Introduction

This chapter contains a report of the results of the research. Included is a restatement of the purpose of the study as well as a review of the population, sample, methodology, and instrumentation used to conduct the study. A summary and discussion of the findings has been organized to address each of the two research questions. Implications for practice are offered along with recommendations for future research.

Purpose of the Study

The purpose of this study was to determine if there is a significant relationship between learning styles and student learning outcomes in an online college mathematics course. In addition, the study was conducted to investigate the relationship of online learning and learning styles to student learning outcomes in the face-to-face environment.

Methodology

The research design for the study was a quasi-experimental design. Because students were already enrolled in either an online or face-to-face course, a convenience sample was used. The population for the research was the students enrolled in online and face-to-face mathematics classes where the curriculum was the same for both the online

and face-to-face courses. Students in face-to-face and online courses were given a

learning styles inventory survey and an initial assessment at the beginning of the course.

At the conclusion of the course, a mathematics test to gauge student achievement was

administered.

Population and Sample

The students sampled attended a non-traditional, private multimedia university

located in the southeast who's population is approximately 8,600 students. The

university runs an accelerated learning environment in which the average student takes

one or two 4-week courses at a time. The sample for this study was drawn from many

degree programs that require students to take a mathematics course entitled College

Mathematics and Algebra (CMA). A total of 437 students participated in the study, 181

face-to-face and 256 online.

Instrumentation

Three instruments were used as measures in the study. An initial assessment

measured prior mathematical knowledge. Questions from the NAEP Question Tool

Database measured students' academic performance. This instrument provided a large

number of valid questions that could be used to select concepts the students learned in the

course. Because social interaction is a distinguishing characteristic between online and

face-to-face classes and the Grasha-Reichmann Student Learning Styles Scales

(GRSLSS) is a social interaction model constructed for use with college students, it was chosen to measure student learning styles.

Summary and Discussion of the Findings

The following two research questions were constructed to guide the study.

1. Do learning styles have a predictive relationship with student achievement in an online college mathematics course?

2. Do the various learning styles among mathematics students in online versus face-to-face courses predict mathematics achievement?

In responding to Research Question 1, as to whether learning styles had a predictive relationship with student achievement, it was determined that there was not a predictive relationship between learning styles and student achievement in an online mathematics course. This was measured using a hierarchical linear regression.

For Research Question 2, as to do various learning styles of mathematics students predicted mathematics achievement, it was found that learning style did not have an influence on predicting achievement in online students versus face-to-face students. Two hierarchical linear regressions were run to address this question, one for online and one for face-to-face classes.

A series of ANCOVA tests were run to examine the presence of any relationships between a given demographic and course modality when describing differences between student test scores while controlling for prior academic performance. The demographics of interest included ethnicity, gender, age, and academic program. When examining

demographics alone without respect to modality, there was no significance in course performance between students in various ethnicity, gender, or age groups.

In regard to ethnicity, there was no significant difference in course performance when considering only modality. There was no significance by gender alone, but there was a significant difference when examining differences in mathematics test performance by the interaction between gender and modality. The female students in the face-to-face class outperformed the male students. But in online courses, the male students outperformed the female students.

In regard to age, there was no significant difference in course performance when considering only modality. There was a significant difference in course performance, however, when examining differences in mathematics test performance by academic program. Film students scored significantly higher than did those in the Entertainment and Recording Arts groups. The rest of the groups did not differ significantly from one another. There was no significant difference in course performance when examining differences in mathematics test performance by the interaction between academic program and modality while controlling for initial assessment performance.

In observing other results of the study, a few themes were apparent. When compared to the participatory learners, collaborative students had higher scores in the face-to-face modality than did their online student counterparts. When compared to the participatory learners, dependent learners showed a decrease in scores in the face-to-face modality, but online dependent learners showed higher scores. Overall, online students outscored face-to-face students.

The body of research focused on the differences in the ways in which individuals perceive and process information has been referred to as learning style theory (Husch, 2001) and was the basis of this study. The conceptual framework for this study was grounded in the literature of learning style theory and its possible influence on student achievement. Grasha's (2002) theory of learning styles served as the theoretical construct. He posited that college educators should know their students' learning styles and reflect on their teaching practices and techniques to meet the needs of their students. Grasha articulated the belief that taking learning style into account when developing course material can help college educators distinguish gaps between their instructional strategies and the ways students learn.

In the review of the literature for the present study, studies that did and did not yield significance when addressing the research questions of the study were discussed. Significance was shown between learning style and mathematics achievement in a few studies (Rooney, 1991; Treacy, 1996). On the other hand, a study conducted by Matthews & Newman (1994) resulted in no significance between mathematics achievement and learning style. Significance was determined when addressing the relationship between learning style and online mathematics courses (Jai, 1994; Bell, 1988). In Clariana's (1997) research, addressing the relationship between learning style and achievement in online mathematics class, no significance was found. When comparing achievement in online versus face-to-face mathematics courses, some researchers found significance (Esmaeili, 2001; Manochehri & Young, 2006), but others did not (Ryan, 2001; Smith, 1996; Weems, 2002).

In the present study, no significant differences between learning styles and achievement were identified. These findings could indicate that (a) an implementation of education techniques for younger mathematics students to be successful in an online mathematics class may not be needed, (b) students may not necessarily need to consider their learning styles in their decisions to enroll in online or face-to-face mathematics courses; and (c) instructors may not need to be overly concerned that they adjust their instruction or make special efforts to help students adjust to modes of instruction based on their students' learning styles. On the other hand, actions regarding the lack of significance in this study should be tempered.   Many variables such as access to tools, technology experience, study habits, goals, learning preferences, purposes, lifestyles, cognitive ability, motivation and personal traits could have affected the success of online students (Klanja-Milicevic et al, 2011; Schrum and Hong, 2001).

Though learning styles did not prove to be significant in this study, it is still advised that instructors be understanding of different learning styles (Mupinga et al., 2006) to address the different learning needs of all students.   Also, it is important to use techniques that would favor and improve learning, e.g., observing learning styles (Klanja-Milicevic et al., 2011) to insure students with different learning abilities are given a fair chance of learning the material. The experience of the instructors, ranging from 6 to 16 years of teaching, could be a strong factor in the outcome of this study. Given the years of practice, it is highly possible the instructors were teaching appropriately and addressing the needs of the learners. In general, teachers should not teach using one style of learning, for everyone learns differently. Without careful consideration of differences

in learning, educational practices may deprive able people of opportunities and provide advantages to those who are less able (Morgan, 2010; Sternberg et al., 2008).

Other factors may have contributed to the non-significance found in this research. The growth of online platforms to promote social presence in online courses may provide students a feeling of community which is appealing to collaborative and participant learning styles. Also, people do not have just one style and might be able to use a different style depending on the course they are taking (Grasha, 2002; Sternberg & Grigorenko, 1997). A third consideration is that students' conceptions about the learning style questions and the type of learner they would be may lead to students not being completely honest in their answers. For example, one question on the learning styles assessment required students to respond to the following statement, "I don't want to attend most of my classes." Some students who might strongly agree with this statement might not want to be perceived a certain way and therefore selected a different response. Another possible factor was the accelerated speed of the course. Traditional college classes are 15 weeks. If the course chosen for the study had been 15 weeks rather than four, results may have varied. Also academic integrity of students poses another concern. Though students in face-to-face classes were monitored by instructors, the same conditions were not imposed on students taking the course online. They were relied upon as trustworthy to complete their own assignments and when taking the mathematics assessment. Should any of these conditions not have been present, the validity and accuracy of the data collected could have been skewed.

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Reflecting upon themes and demographic information, justifications can be made that relate to the researcher's experiences as an instructor. It is not surprising that the collaborative students had higher scores compared to the participatory learners in the face-to-face modality. Similarly, it was not surprising that the opposite was true for the online modality. It is much more difficult for online students to collaborate than those engaging in face-to-face contact; thus, it is logical that collaborative students performed better in group settings. Also the fact that dependent learners did better than participatory learners in the online modality was not surprising. Dependent learners are often not very curious about their courses and put forth minimum effort in order to pass. In contrast, participatory learners enjoy class and do as many activities as possible. The online setting affords much less discussion and has to be very clear in direction, because there is no immediate feedback from instructors for student questions. Therefore, the dependent students are able to do the work in a very linear fashion without extra activities or dialogue and are more successful in an online environment.

Recommendations for Practice

In general, awareness of the process students use to learn information can potentially lead to pedagogy that will improve student understanding (Evans, Coolsc, & Charelsworth, 2010).

> "There are at least three major motivations for studying cognitive styles: providing a link between cognition and personality; understanding, predicting, and improving educational achievement; and improving vocational selection, guidance, and, possibly, placement" (Sternberg & Grigorenko, 1997, p. 702).

Even though the results were not significant for this study, when designing courses, particularly online, learning style has been viewed as a major factor in student satisfaction and academic achievement (Phipps & Merisotis, 1999). Also since a range of learning styles existed in this study, educators should still consider learning styles when designing and teaching courses because knowing different ways that students process information can greatly help in student understanding (Evans et al., 2010). The literature for this study focused on achievement, but student understanding should also be an objective for educators.

<div align="center">Recommendations for Future Studies</div>

Though this study did not show significance regarding learning gains for college students when considering learning styles, other studies have done so (Aragon et al., 2002; Dunn & Griggs, 2000; Dunn & Stevenson, 1997). Also there are not many studies in which learning styles and achievement in online mathematics courses have been examined. Therefore, additional studies regarding learning style and student achievement should be conducted. Possible adaptations to the sample in regard to size, location, and class length might produce different results. Other possibilities include using different instruments to measure learning styles and student achievement. Though the students were to complete the learning styles assessment with their overall learning in mind, giving the students the learning style assessment outside of a mathematics class might result in different results. Due to the use of convenience sampling, the sample size, and the characteristics of the selected sample, the results of the study were not able to be

generalized for all online students. However, when identifying the relationship between learning style and online mathematics student achievement, a foundation was able to be established for future large scale research and underlying significant characteristics for future online mathematics students. Given the sample size of this study, the results can be confirmed or dismissed based on replication of the study at another university to see if the same results were found.

As online education continues to grow and more and more colleges and universities are adopting this modality (Allen & Seaman, 2007; Xu & Jaggars, 2011), more research is needed to insure students are being taught the best way. Teaching mathematics online is a fairly new pedagogy (Engelbrecht & Harding, 2004, 2005b), and courses offered in this modality continue to increase in numbers (Beaudoin, 2002). Therefore, most research regarding best practices with teaching mathematics online will be helpful. Since learning style was not significant in this study it is imperative to continue research to see what variables are factors in being successful in an online mathematics class.

APPENDIX A
INSTITUTIONAL REVIEW BOARD APPROVAL

University of Central Florida Institutional Review Board
Office of Research & Commercialization
12201 Research Parkway, Suite 501
Orlando, Florida 32826-3246
Telephone: 407-823-2901 or 407-882-2276
www.research.ucf.edu/compliance/irb.html

Approval of Exempt Human Research

From:	**UCF Institutional Review Board #1**
	FWA00000351, IRB00001138
To:	**Bridget Steele**
Date:	**September 15, 2011**

Dear Researcher:

On 9/15/2011, the IRB approved the following activity as human participant research that is exempt from regulation:

Type of Review:	Exempt Determination
Project Title:	Examination of an accelerated online college mathematics course:
	Correlation between learning styles and student achievement
Investigator:	Bridget Steele
IRB Number:	SBE-11-07865
Funding Agency:	
Grant Title:	
Research ID:	N/A

This determination applies only to the activities described in the IRB submission and does not apply should any changes be made. If changes are made and there are questions about whether these changes affect the exempt status of the human research, please contact the IRB. When you have completed your research, please submit a Study Closure request in iRIS so that IRB records will be accurate.

In the conduct of this research, you are responsible to follow the requirements of the Investigator Manual.

On behalf of Sophia Dziegielewski, Ph.D., L.C.S.W., UCF IRB Chair, this letter is signed by:

Signature applied by Joanne Muratori on 09/15/2011 03:55:25 PM EDT

IRB Coordinator

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APPENDIX B
ASSESSMENT OF MATHEMATICS ACHIEVEMENT

Please answer the following questions to the best of your ability. You may use a calculator.

1. Marty has 6 red pencils, 4 green pencils, and 5 blue pencils. If he picks out one pencil without looking, what is the probability that the pencil he picks will be green?
    a. 1 out of 3
   b. 1 out of 4
    c. 1 out of 15
    d. 4 out of 15

2. Michelle has a container with 3 quarts of juice. She pours 1 cup of juice for each person. At most, how many people can she serve? (1 quart = 4 cups)
    a. 4
    b. 7
    c. 8
    d. 12

3. In which of the following numbers is the digit 6 in the hundredths place?
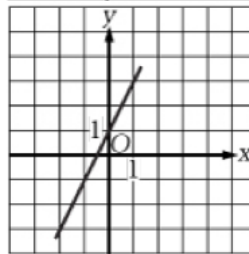   a. 682.3
    b. 382.6
    c. 6.832
    d. 4.836
    e. 2.862

4. If $x = 2n + 1$, what is the value of x when $n = 10$?
    a. 11
    b. 13
    c. 20
    d. 21
    e. 211

5. If $15 + 3x = 42$, then $x =$
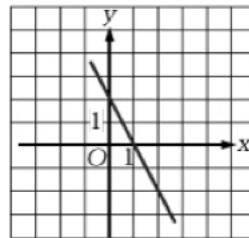   a. 9
    b. 11
    c. 12
    d. 14
    e. 19

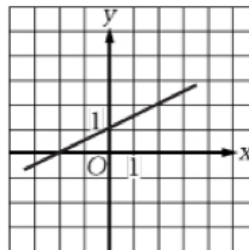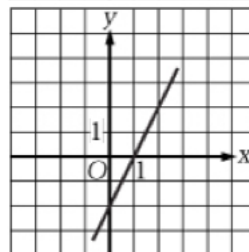6. Which of the following is the graph of the line with equation $y = -2x + 1$?
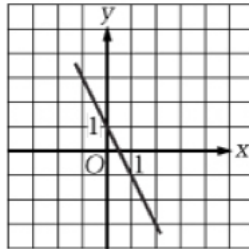
a.

b.

c.

d.

e.

7. Which of the following is equal to $6(x + 6)$?
   a. $x + 12$
   b. $6x + 6$
   c. $6x + 12$
   d. $6x + 36$
   e. $6x + 66$

$$\begin{cases} x + 2y = 1 \\ 2x - y = 7 \end{cases}$$

8. In the solution of the system of equations above, what is the value of x?
   a. -1
   b. 2
   c. 3
   d. 4
   e. 5

9. 4, 8, 3, 2, 5, 8, 12
   What is the median of the numbers above?

   a. 4
   b. 5
   c. 6
   d. 7
   e. 8

10. The diameter of a red blood cell, in inches, is 3×10^{-4}. This expression is the same as which of the following numbers?
    a. 0.00003
    b. 0.0003
    c. 0.003
    d. 3,000
    e. 30,000

11. N stands for the number of stamps John had. He gave 12 stamps to his sister. Which expression tells how many stamps John has now?
    a. N+12
    b. N-12
    c. 12-N
    d. 12 x N

12. Of the following, which is the closest approximation of a 15 percent tip on a restaurant check of $24.99?
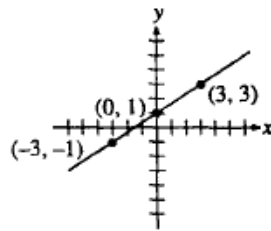   a. $2.50
    b. $3.00

c. $3.75
d. $4.50
e. $5.00

13. Ken bought a used car for $5,375. He had to pay an additional 15 percent of the purchase price to cover both sales tax and extra fees. Of the following, which is closest to the total amount Ken paid?
    a. $806
    b. $5,510
    c. $5,760
    d. $5,940
    e. $6,180

14. $3^3 + 4(8 - 5) \div 6$
    a. 6.5
    b. 11
    c. 27.5
    d. 29
    e. 34.16

15. What is the slope of the line shown in the graph above?
    a. 1/3
    b. 2/3
    c. 1
    d. 3/2
    e. 3

16. Which statement is true?
    a. $352 > 759$
    b. $442 > 436$
    c. $518 > 819$
    d. $883 < 794$

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17. If $\dfrac{2}{25} = \dfrac{n}{500}$, then $n =$
   a. 10
   b. 20
   c. 30
   d. 40
   e. 50

18. Pencils sell individually for $0.07 each or in packs of 12 for $0.79 per pack. How much is saved when 24 pencils are purchased by the pack instead of individually?
   a. $0.01
   b. $0.05
   c. $0.10
   d. $0.72
   e. $1.44

19. What percent of 175 is 7?
   a. 4%
   b. 12.25%
   c. 25%
   d. 40%

20. A savings account earns 1 percent interest per month on the sum of the initial amount deposited plus any accumulated interest. If a savings account is opened with an initial deposit of $1,000 and no other deposits or withdrawals are made, what will be the amount in this account at the end of 6 months?
   a. $1,060.00
   b. $1,061.52
   c. $1,072.14
   d. $1,600.00
   e. $6,000.00

APPENDIX C
GRASHA-REICHMANN STUDENT LEARNING STYLES SCALES (GRSLSS)

Grasha-Reichmann Student Learning Style Inventory

The following questionnaire has been designed to help you clarify your attitudes and feelings toward the courses you have taken thus far. There are no right or wrong answers to each question. However, as you answer each question, form your answers with regard to your general attitudes and feelings toward **all** of your courses.

Respond to the items listed below by using the following scale.

Use a rating of 1 if you strongly disagree with the statement.
Use a rating of 2 if you moderately disagree with the statement.
Use a rating of 3 if you are undecided.
Use a rating of 4 if you moderately agree with the statement.
Use a rating of 5 if you strongly agree with the statement.

1. I prefer to work by myself on assignments in my courses.
2. I often daydream during class.
3. Working with other students on class activities is something I enjoy doing.
4. I like it whenever teachers clearly state what is required and expected.
5. To do well, it is necessary to compete with other students for the teacher's attention.
6. I do whatever is asked of me to learn the content in my classes.
7. My ideas about the content often are as good as those in the textbook.
8. Classroom activities are usually boring.
9. I enjoy discussing my ideas about course content with other students.
10. I rely on my teachers to tell me what is important for me to learn.
11. It is necessary to compete with other students to get a good grade.
12. Class sessions typically are worth attending.
13. I study what is important to me and not always what the instructor says is important.
14. I very seldom am excited about material covered in a course.
15. I enjoy hearing what other students think about issues raised in class.
16. I only do what I am absolutely required to do in my courses.
17. In class, I must compete with other students to get my ideas across.
18. I get more out of going to class than staying at home.
19. I learn a lot of the content in my classes on my own.
20. I don't want to attend most of my classes.
21. Students should be encouraged to share more of their ideas with each other.
22. I complete assignments exactly the way my teachers tell me to do them.
23. Students have to be aggressive to do well in courses.
24. It is my responsibility to get as much as I can out of a course.
25. I feel very confident about my ability to learn on my own.
26. Paying attention during class sessions is difficult for me to do.
27. I like to study for tests with other students.
28. I do not like making choices about what to study or how to do assignments.
29. I like to solve problems or answer questions before anybody else can.
30. Classroom activities are interesting.

31. I like to develop my own ideas about course content.
32. I have given up trying to learn anything from going to class.
33. Class sessions make me feel like part of a team where people help each other learn.
34. Students should be more closely supervised by teachers on course projects.
35. To get ahead in class, it is necessary to step on the toes of other students.
36. I try to participate as much as I can in all aspects of a course.
37. I have my own ideas about how classes should be run.
38. I study just hard enough to get by.
39. An important part of taking courses is learning to get along with other people.
40. My notes contain almost everything the teacher said in class.
41. Being one of the best students in my classes is very important to me.
42. I do all course assignments well whether or not I think they are interesting.
43. If I like a topic, I try to find out more about it on my own.
44. I typically cram for exams.
45. Learning the material is a cooperative effort between students and teachers.
46. I prefer class sessions that are highly organized.
47. To stand out in my classes, I complete assignments better than other students.
48. I typically complete course assignments before their deadlines.
49. I like classes where I can work at my own pace.
50. I would prefer that teachers ignore me in class.
51. I am willing to help other students out when they do not understand something.
52. Students should be told exactly what material is to be covered on exams.
53. I like to know how well other students are doing on exams and course assignments.
54. I complete required assignments as well as those that are optional.
55. When I don't understand something, I first try to figure it out for myself.
56. During class sessions, I tend to socialize with people sitting next to me.
57. I enjoy participating in small group activities during class.
58. I like it when teachers are well organized for a session.
59. I want my teachers to give me more recognition for the good work I do.
60. In my classes, I often sit toward the front of the room.

APPENDIX D
STUDENT DEMOGRAPHIC QUESTIONNAIRE

Demographic Information

1. What type of College Mathematics and Algebra class are you currently enrolled in?
    a. Face-to-face
    b. Online
2. What is your program?
    a. Computer Animation
    b. Digital Arts
    c. Entertainment Business
    d. Film
    e. Game Art
    f. Game Design
    g. Game Development
    h. Graphic Design
    i. Internet Marketing
    j. Music Business
    k. Music Production
    l. Recording Arts
    m. Recording Engineering
    n. Show Production
    o. Web Design and Development
    p. Other
3. What is your race or ethnic background?
    a. American Indian or Alaska Native
    b. Asian
    c. African American or Black
    d. Hispanic or Latino
    e. White
    f. Other
4. What is your age?
5. What is your sex?
    a. Female
    b. Male

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