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Learning Style Preferences and College Student Achievement in Introductory Science Classes

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LEARNING STYLE PREFERENCES AND COLLEGE STUDENT ACHIEVEMENT IN INTRODUCTORY SCIENCE CLASSES

DISSERTATION

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By

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Area of Specialization: Higher Education Administration

LEARNING STYLE PREFERENCES AND COLLEGE STUDENT

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ABSTRACT

LEARNING STYLE PREFERENCES AND COLLEGE STUDENT ACHIEVEMENT IN INTRODUCTORY SCIENCE CLASSES

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Barry University - 2012

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Purpose

The purpose of this study was to compare the learning style preference of students enrolled in introductory science classes and their achievement as measured by the grade they earned in the class at the end of the semester. The learning style preference of the participants was assessed using the Felder and Soloman (1999) Index of Learning Styles (ILS), which is based on Jung (1971) and Kolb (1981) theories of information processing, and on Dewey (1944), Piaget (1972), Vygotsky (1978), and Claxton and Murrel (1978) theories on learning.

Methodology

Learning Style Inventories have been used mainly in the development of teaching techniques for the social science classroom at the high school level (Anderson & Adams, 1992; Banks, 2003), and for the development of curriculum at the undergraduate level in the agricultural sciences (Cano, 1999). Only a few studies have been conducted on the significance of learning style preferences on achievement. Dunn and Dunn (1979), Claxton and Murrell (1987), and Anderson and Adams (1992) conducted studies on the

significance of learning style preference and achievement for high school students in social sciences, and found that the learning style preference related directly to their achievement at this level of education. Roig (2008) conducted a study on the effect of learning style preference on achievement for biology majors, and found that learning style preference does not play a significant role in achievement for biology students enrolled in introductory biology at the college level.

The population chosen for this study was students enrolled in introductory science classes, which produced a sample consisting of 188 participants. The data collected were analyzed by One-way ANOVA with the learning style preference as the independent variable and the grade achieved at the end of the class as the dependent variable. The limitations in this study were the non-random selection of the classes, the exclusion of most of the science areas, and the homogeneity of teaching and class management styles of the instructors.

Findings

The results from the One-way ANOVA indicate that there was no significant relationship between learning style preference and grade ($p > .05$). These results confirm the findings obtained by Roig (2008) for students enrolled in introductory science courses at the college level, but contradict the findings from previous studies (Dunn & Dunn, 1979; Claxton & Murrell, 1987; Anderson & Adams, 1992) in social sciences at the high school level.

The findings of the study suggest that this research should be replicated using a larger random population of science majors enrolled in advanced science classes. The evaluation of achievement should be conducted using tests developed by the national science organizations to evaluate knowledge in the area being taught. The results also suggest that a qualitative study should be conducted on the experiences of the instructors teaching these classes, and on the experiences of the students involved in the study.

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DEDICATIONS

To the three most important persons in my life: Sandy, Jessica, and Jorge, who have always supported and encouraged me. Your love, patience and understanding made this endeavor possible.

In loving memory of my brother and friend, Rafael Fernando Salinas, whose untimely death left a big void in both my heart and my life.

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CHAPTER I

THE PROBLEM

Introduction

From the time when people started exchanging ideas in the pursuit of knowledge, educators have wondered how a person learns and what factors influence the acquisition of knowledge. Kolb, A. Y. and Kolb, D. A. (2005) defined learning as the result of a combination of assimilating and transforming experiences through observation and reflection. According to Kolb and Kolb, and Zull (2002) the learning process is based on exposure to immediate and concrete experiences that must be processed by the brain. Zull defined learning as the result of being exposed to an experience, thinking about it (abstracting), and acting on it.

Kolb (1984) described the acquisition of knowledge as a three-stage process:

- The first stage, which Kolb called the acquisition stage, spans from the time of birth to late adolescence. In this stage, the individual cultivates basic mental abilities and develops cognitive structures
- The second stage, the specialization stage, spans from the time formal schooling starts to the early stages of work, and includes personal experiences of adulthood. In this stage, the knowledge base and the learning preferences of an individual are shaped by social, educational, and organizational socialization
- The third stage, or integration stage, progresses from mid-career to late-life. In this stage, knowledge is acquired through non-dominant modes of learning

Kolb and Kolb (2005) defined learning style as the result of two different, but complementary responses: an individual's biological response to his/her natural environment and a psychological response to his/her social environment, which includes cultural background (Piaget, 1972; Vygotsky, 1978; Claxton & Murrell, 1987; Claxton & Murrell, 1988; Tsui, 1996). People use different learning styles to adapt to the environment in which the learning takes place; however, each person has a preferred learning style which he/she uses to maximize his/her ability to assimilate, process, and retain information (Claxton & Murrell, 1987; Claxton & Murrell, 1988; Diaz & Carnal, 1999; Tsui, 1996; Baumgartner, 2001).

Dunn, Griggs, and Dunn (1993) stated that knowing the learning style preference of a student is important for his/her formative education. Learning style preference is especially important in the formulation of curriculum for the secondary and post-secondary systems in 21st century America, because these school systems are populated by students from different cultures and social backgrounds. According to Baumgartner (2001), Claxton and Murrell (1987), and Claxton and Murrell (1988) these students have their own, unique learning style preference which is shaped by their social and cultural environment. Anderson and Adams (1992) studied the relationship between the teaching styles of a selected group of high school teachers and the learning styles of their students, and found that there was a positive correlation between the teaching style used and student achievement when the teachers adjusted their teaching styles to address the learning styles of their students. This confirms previous studies by Dunn et al. that students perform better when taught using a teaching style that addresses their learning style preference.

Kolb’s (1981) Experiential Learning Theory (ELT) states that knowing the learning style preference of the students allows the instructor to tailor his/her teaching style to maximize the learning experience of the students in his/her classroom. The majority of the research in the areas of learning styles and classroom achievement has been conducted with middle and high school students enrolled in social science classes. The limitation of these studies has been that, according to Kolb (1984), the majority of the students participating were at the stage in which they had not yet developed a learning style preference.

The three stages of knowledge development (Kolb, 1984) leading towards one's learning style are: the acquisition stage, the specialization stage, and the integration stage. Kolb states that students enrolled in post-secondary education are at the specialization stage of knowledge development, which is the stage where the learning style preference of a person is fully developed. Very little research has been conducted on the effect of learning style preference of students on their achievement in post-secondary science education. Roig (2008) conducted a study to determine the effect of learning style preference on achievement for students enrolled in introductory biology classes, and found no effect of learning style preference on student achievement. A few studies on the effect of learning style preference on achievement for students enrolled in the applied sciences and technology have been conducted with a positive correlation between learning style and achievement (Felder & Silverman, 1998; Torres & Cano, 1994; Murphy, Gray, Straja, & Bogert, 2004)

Felder and Silverman (1998) conducted research on the learning style preference of engineering students and their achievement, and found a positive correlation between learning style preference and achievement. Torres and Cano (1994) conducted a study on the effect of teaching style and learning style preference of students enrolled in agricultural courses, and Murphy, Gray, Straja, and Bogert (2004) conducted a similar study with dentistry students and they both found a direct correlation between learning style preference and achievement.

When one considers curriculum alignment and learning style preference for the purpose of properly preparing a future pool of scientists, Pitts (2009) theorized that aligning the science curriculum with the learning style preferences of students would eventually attract more students into sciences. This will eventually produce more scientists capable of performing basic research and development. It is important we consider these findings, because the United States is currently facing a research and development crisis due to the predicted retirement of a very large percentage of the Baby Boomer generation (persons born between 1946 and 1964). The 2006 Science and Engineering Indicators Report of the National Science Foundation (NSFS&E) reported that approximately 29% of the current work force performing academic and industrial research and development is over 50 years old, and will be retiring by the end of the second decade of the present century. The NSFS&E predicts that by the end of the 2020s approximately ten million Baby Boomers will be retiring, with over two million of them retiring from science-related jobs. Goodman (2005), Dohn (2000), Matt (2001), and McClellan and Holden (2001) predict that by the end of the 2040s a total of 77 million persons will retire with 28 million of them retiring from science-related fields.

The 2008 Report of the U.S. Census Bureau reports that the number of Generation-X individuals (persons born between 1965 and 1982) trained in basic sciences and capable of taking over the vacant positions left vacant by the Baby Boomers is very small, and must be complemented by scientists from the Millennial generation (persons born between 1983 and 2001) to make up for the deficit. The gap between the number of predicted vacancies and the pool of scientists that can fill them is so large that it places the U.S. in a very precarious situation, and threatens its position as the leader in scientific research and development, and the industrial manufacturing that results from it.

Further evidence supports the decline of student interest in entering fields associated with mathematics and sciences. According to the 2010 Digest of Education Statistics of the National Center for Education Statistics (NCES) (http://www.nces.ed.gov/programs/digest/) the U.S. has been facing a net decline in enrollment in post-secondary education in science and technology. This trend became evident in the early 1970s when the number of graduate degrees conferred to native or nationalized U.S. students in the sciences, technology, engineering, and mathematics fields started to decline. The 2006 U. S. Department of Education, National Center on Education and the Economy Report indicates that only 8% of the graduating high school students taking the Stanford Achievement Test (SAT) in the U. S. intend to major in either science, technology, engineering, or mathematics. The low enrollment in sciences is creating a critical and urgent economic, health, and security need to expand the population of students interested in pursuing a career in science, technology, engineering, and mathematics (Bloom, 2008)

There is, therefore, an obvious need to begin to tackle this problem. To that end, this study was conducted to determine the effect of the learning style preferences of science students on their achievement as determined by the grade obtained upon completion of the class. A positive correlation between learning style preference and achievement in sciences could be used as a guide for the development of curriculum based on differential instruction and learning styles, to encourage enrollment, and increase retention and graduation rates in science. This study was based on Kolb's (1984) second stage of knowledge development, which he defined as the stage in which young adults develop their learning style preferences as a result of their social and cultural environment (Social Constructivism).

The college in which this study was conducted is the largest Hispanic Serving Institution (HIS) in the U.S. with an enrollment in excess of 160,000 students (www.mdc.edu/ir). The largest number of the students attending this college consists of naturalized immigrants and international students of different cultural and socio-economic backgrounds. Modifying the present curriculum to address the learning style preference of these students could be used to generate interest in students of all backgrounds to enroll, succeed, and graduate in one of the science fields, and encourage them to pursue a post-baccalaureate degree in the basic sciences. Increasing the graduation rate in sciences, especially at the Master's and Ph. D. levels, could alleviate some of the demands that will be placed on American academic and industrial research and development by the predicted retirement of the Baby Boomers in mid-century.

Statement of the Problem

According to the 2008 Report of the U. S. Census Bureau, the scientific community in the United States is facing a problem due to the predicted retirement by mid-century of the majority of the scientific workforce, and the very small pool of native or nationalized American scientists qualified to fill in these positions. The 2006 Science and Engineering Indicators Report of the National Science Foundation (NSFS&E)

documented that the largest percentage of the students enrolled in post-baccalaureate Master's and Doctoral programs in science, technology, engineering, and mathematics at American research universities are non-native students who plan to return to their home countries to work in their fields of specialty upon graduation.

The demand for a qualified workforce in science will not be met by the present number of American born or naturalized students pursuing careers in science at American institutions. The disparity between future vacancies and the future pool of qualified scientists capable of filling them threatens the position of the U.S. as the leader in scientific research and development, and in science-related manufacturing.

As we look to our secondary schools for potential research and development science majors, Ekstrom, Goetz, and Rock (1988) inform us that the percentage of American-born or nationalized students graduating from high school with proficiency in science or mathematics is very small and few of them will pursue a career in sciences. The number of students graduating with a B.S. degree in sciences and continuing with a post-baccalaureate degree represents an even smaller fraction (Ekstrom et al., 1988).

The low percentage of students pursuing a career in sciences can be attributed to many factors. Socioeconomic status, urban/rural segregation, educational family history, academic and/or experiential access are some of the factors that may deny, and/or inhibit students the opportunity to pursue careers in sciences. According to Ekstrom et al. (1988) an important factor discouraging students from pursuing a career in sciences is the lack of exposure to sciences during their formative years. Dunn, Griggs, and Dunn (1993) theorized that the deficiency created by the lack of exposure at the lower educational levels can be overcome by aligning the teaching styles of the professors in the science classrooms in post-secondary education with the learning styles of their students.

Purpose Statement

Reports from governmental agencies, academic institutions, and industrial facilities predict a shortage of scientists by mid-century. To alleviate this deficit the number of graduating scientists has to be increased, placing a significant demand on American secondary and post-secondary institutions to train the pool of scientists capable of filling this void. Adjusting the teaching styles of the instructors to accommodate the learning style preferences of the students may encourage students to pursue careers in sciences. An increase in enrollment in sciences could result in an increase in the graduation rate producing enough scientists to off-set the predicted shortage by midcentury, assuming that these graduates will go into science-related careers where academic and industrial research and development are performed (Bloom, 2008).

Prior studies conducted with high school students in social science indicate that there is a correlation between the preferred learning style of students and their achievement as determined by grade obtained when the teaching style of the instructor is matched with the learning style of the students (Anderson & Adams, 1992; Claxton & Murrell, 1987; Claxton & Murrell, 1988). This kind of study, however, has not been conducted consistently with science students in post-secondary institutions.

The purpose of this study was to determine the effect of learning style preferences on student achievement in selected post-secondary science classes as measured by the grade obtained by the student upon completion of the course.

Background and Significance

The 2006 National Science Board, Science and Engineering Indicators (NSBI) reported that students in the current K-12 system have less access to a solid science and mathematics education than students did in previous decades due to a lack of qualified instructors, lack of access to modern equipment and laboratory facilities, and outdated text books. These factors deny current K-12 students the opportunity to acquire the necessary prerequisites in sciences needed for admission to American colleges and universities. In 2006 NSFS&E reported that over the last decades the United States has been experiencing a decrease in the number of qualified science instructors at the college and university levels.

All these reports show that as the population of students in the current K-12 system increases, their level of preparation, especially in sciences decreases. Future high school graduates will be unprepared to continue their education in any of the science fields, posing a potentially significant threat to the scientific community in America. A lack of qualified science educators at all levels of the American educational system compounds the problem. Lack of access to good schools and qualified teachers is a common problem encountered by American students (Oakes et al., 1990). There will not be enough trained scientists to fill future positions in scientific research and development.

Research Question

This study was conducted to determine the effect of learning style preferences on urban student achievement in selected post-secondary introductory sciences classes as measured by the grade obtained in the course. The question that guided this study was based on a recognized relationship between learning styles as determined by the

Inventory of Learning Styles (ILS), as the independent variable, and achievement in the form of a final grade in science classes, as the dependent variable.

The question addressed in this study was: What effect does the learning style preference of students enrolled in post-secondary introductory astronomy, biology, and chemistry classes have on achievement as measured by the grade obtained at the end of the course?

Hypotheses

The independent variable for this research study was the learning style preference of the students enrolled in a science classroom of an urban college in South Florida. The dependent variable was student achievement as measured by the final grade obtained at the end of the course. The hypotheses that relate to the research questions were:

The Null, or statistical, hypotheses

H_{01}: There is no effect of the learning styles on achievement in astronomy classes

H_{02}: There is no effect of learning styles on achievement in biology classes

H_{03}: There is no effect of learning styles on achievement in chemistry classes

The research hypotheses

H_{A1}: There is an effect of learning styles on achievement in astronomy classes

H_{A2}: There is an effect of learning styles on achievement in biology classes

H_{A3}: There is an effect of learning styles on achievement in chemistry classes

Theoretical Framework

The theoretical framework that guided this study was based on the Experiential Learning Model (ELM) developed by Kolb (1984). The ELM is based on the theories on learning developed by prominent 20th century scholars such as Dewey (1963), Lewin and Grabbe (1945), and Piaget (1972).

From Dewey's *Pragmatism*, Kolb derived the concept of experiential learning, which is the result of learning from exposure to experiences. From Lewin's *Social Psychology* Kolb developed the idea of action research, or collaborative learning. From Piaget's *Epistemology* Kolb defined the learning process as the result of assimilating new information and accommodating it to the new environment. Kolb used these theories to develop the first systematic and comprehensive theory of experiential learning, or the Experiential Learning Model (ELM). The ELM served as the basis in the development of Kolb's Learning Styles Inventory (LSI), which is used to assess individual learning styles.

Learning Styles are defined as the ways in which individuals use information and stimuli to gain cognitive knowledge (Felder & Silverman, 1998; Vygotsky, 1978). In this study, the learning styles of students enrolled in science classes at an urban college in South Florida were assessed using the Felder and Soloman (2000) Index of Learning Styles (ILS). The ILS is the result of the work done by Felder and Silverman (1998) on learning style dimensions. The ILS is a comprehensive survey tool that assesses the learning style preferences of students based on four of the five dimensions of learning developed by Felder and Silverman (1998). Felder and Silverman dimensions of learning are based on Jung's (1971) psychological theories of perception and Kolb's (1981) theories of learning.

The Felder and Silverman dimensions of learning are based on five areas of knowledge acquisition: active/reflective, sensory/intuitive, visual/verbal, sequential/global, and inductive/deductive. Felder and Silverman, however, theorized that the learning style preference of a student can be accurately measured using only four of the five dimensions, because the inductive/deductive dimension from the ILS is built in the system, at least at the undergraduate level (Felder and Soloman, 2000).

Definition of Terms

The following section provides definitions of terminology used in this study, to ascertain that the reader has the same meaning as the author.

Achievement is defined as the grade obtained upon completion of the course.

Learning style is determined by the score on the Index of Learning Styles questionnaire. The four learning styles delineated by Felder and Solomon are:

- active/reflective
- sensory/intuitive
- visual/verbal
- sequential/global

Non-traditional Student is defined as a student older than twenty-two years of age, enrolled with a load of less than twelve credit hours per semesterr, and attending school mainly in the afternoon or evening hours (www.mdc.edu/ir).

Traditional Student is defined by the college in which the study was conducted as a recent high school graduate, between 18 and 22 years of age, attending day-time classes, and enrolled in twelve credit hours or more per semester (www.mdc.edu/ir).

Assumptions

The present study assumed that:

- The students in the selected classes would complete the surveys honestly by answering the questions in a serious manner

- The grade obtained by the student at the end of the course is an appropriate measure of his/her achievement in the class.
- The instructors in the selected classes would be equally well prepared and motivated
- The students participating in the study would be equally well prepared and motivated

Limitations

In studying the learning style preferences of students enrolled science classes it is important to understand and recognize the following limitations:

- the courses included in the study were not randomly selected; therefore the findings of the study may not be generalized
- the courses selected for this study were introductory science classes that are considered part of the general education curriculum
- the courses selected for the study do not include all of the science courses taught at the urban college where the study was conducted

Chapter Summary

This chapter discusses a problem being faced by the scientific community in America. The problem facing the scientific community in America is the predicted retirement of a large segment of the workforce currently employed in scientific research and development, and manufacturing and the lack of qualified replacements. The number of vacancies created by the retiring Baby-Boomers in the next decades cannot be filled with the present population of scientists or the predicted number of scientists in the future. In order to fill these vacancies, the number of graduating scientists capable of doing research and development must be increased to complement the present number of scientists. This is a difficult task under the present conditions, because the number of high school graduates choosing sciences as a career has been decreasing in the last decades.

A way to increase the number of graduate students in sciences is to increase their enrollment and retention at the post-secondary level, which includes enrollment at the community college level. Higher enrollment and higher retention in sciences at the post-secondary level may lead toward a larger number of Master's and Ph. D. graduates in sciences, to complement the current pool of scientists.

Chapter I also discusses the fundamentals of the relationship between achievement in the classroom and learning style preferences of young adults. The chapter introduces the background for the development of learning style instruments to measure learning style preferences. It discusses the need for using learning style preferences at the post-secondary level, to align the teaching styles of the instructors with the learning style preferences of the students in order to increase enrollment and retention in sciences.

CHAPTER II

REVIEW OF THE LITERATURE

Introduction

Chapter II gives an overview of the literature on which this research was based. The review of the literature pertinent to this research revealed four main themes dealing with students' learning styles and how these learning styles relate to academic achievement. The four themes were:

- Learning theory, as it pertains to the psychology and physiology of the individual, as well as the environmental and cultural conditions that influence how an individual acquires knowledge
- Learning styles, as they pertain to the individual preferences of knowledge acquisition, and the factors that determine the developmental stages necessary to learn
- The effect of learning style preferences on achievement. This theme also includes the instruments that are used to determine learning styles
- Barriers to student achievement, as they pertain to the factors influencing learning style preferences, low enrollment, and lack of performance of students in most post-secondary educational areas, especially in sciences, technology, engineering, and mathematics

Learning theory

Davis, Sumara, and Luce-Kapler (2000) defined learning as a two-step process that is both mechanical and holistic. The mechanical aspect of learning is the individualized, personal component of learning and is based on the psychology and the physiology of the individual, while the holistic aspect of learning is the communal and social aspect of learning that includes the cultural and social environment in which the individual is found. Davis et al. (2000) claimed that the mechanical component of learning is the response to a cause and effect phenomenon. They stated that the modern, post-secondary classroom, where education is conducted in a structured, curriculum-, and competency- based environment, is a typical example of mechanical learning. On the other hand, the holistic theory of learning, according to Davis et al. allows the learner to acquire process, retain, and apply new information in an environment in which the individual is part of a learning community.

Kolb (1984) described learning as the result of a higher mental function development. He stated that learning occurs in three stages: the acquisition stage, the specialization stage, and the integration stage. The first stage, the acquisition stage, is the stage in the learning process in which basic abilities and cognitive structures develop. This stage transpires between birth and early adolescence. The second stage, the specialization stage, is the stage in which external forces, such as personal experiences, social forces, and formal schooling shape the learning process. This stage is characterized by the role that cultural and social environments play in the learning process. The specialization stage spans from formal schooling to early work and personal experiences of adulthood, and according to Kolb is the stage in which the learning style preference of an individual is developed. The third and final stage, the integration stage, is the learning stage in which non-dominant modes of learning are expressed in work and personal life, and extend from mid-career to later life. The learning style preference of an individual, which according to Kolb (1984) is developed during the specialization stage, is shaped by culture and social environment.

The majority of the students enrolled in the American community college system find themselves in Kolb's specialization stage, which is the stage where the learning style preference is fully developed. The American community college system reflects the most diverse population of students of all the post-secondary institutions in the U.S. These students belong to different cultural and socio-economic backgrounds; therefore teaching them in a teaching style that addresses their learning style preference may encourage them to pursue careers in science.

Learning Styles

Learning styles are defined by Claxton and Murrel (1987), and Claxton and Murell (1988) as a collection of diverse individual physiological and psychological responses to physical environmental conditions that determine how an individual perceives, acquires, processes, and understands information. When used as class-management tools, learning styles provide the instructor with the basic background on the most efficient way to deliver information to the students in the classroom (Felder & Silverman, 1988; Felder & Silverman, 1998). Dunn, Griggs, and Dunn (1993) reported that when students are taught using their preferred learning style, they show an improvement in academic achievement as a result of a greater comprehension and retention of the materials being taught.

Learning style preferences have led to the development of learning style inventories to measure the dimensional preferences used by an individual in the learning process. In the late 1970s educators and researchers alike started developing learning style instruments to determine the learning style preference of students, but the most reliable and most used modern learning style measuring instruments were developed based on the research carried out by Curry (1987). Curry conducted research on the learning preferences of students, which he used to facilitate, structure, and validate successful learning in the classroom.

There are numerous learning style inventories that can be used to measure learning style preferences; however, they all can be classified in three distinctive categories (Pitts, 2009):

- Instructional and environmental preferences
- Information-processing preferences
- Personality-related preferences

The learning style inventory used in this study was the Felder and Soloman Index of Learning Styles (ILS) which falls in the information-processing preference category. The ILS is therefore very suited to study the effect of learning style preferences of science students on their achievement in the classroom. Felder and Silverman (1988) discussed the importance of learning style preferences in the development of teaching styles in the science classroom, and stated that matching learning styles with teaching styles maximizes the learning/teaching experience, thus improving performance and reflecting greater learning (Pitts, 2009). The Felder and Solomon ILS was developed based on Jung’s (1971) psychological profiles for perception and Kolb’s (1981) developmental theories of information processing.

Felder and Silverman (1998) reported contradictions between the learning style preferences of science students and the traditional teaching styles used in most post-secondary science classrooms. Tobias (1990) writes that students participating in post-secondary science education have a different learning style preference than students enrolled in other areas of the curriculum, and that the teaching style in the post-secondary science classroom should be tailored to fulfill these needs. Felder and Silverman conducted research on the learning style preferences of engineering students to test this theory, and reported a direct correlation between knowledge acquisition ability and experiences, and learning style preferences and teaching styles.

Felder and Silverman (1988) developed a Learning Styles Dimensions Inventory (LSDI) based on Kolb's (1981) Learning Style Inventory (LSI), to provide post-secondary science instructors with a tool to develop teaching styles to better serve the needs of science students based on their learning style preferences. Felder and Silverman's philosophy was that once the instructor knows the learning style preference of his/her students, he/she could use teaching styles suited to better serve the learning needs of his/her students.

Felder and Silverman (1988) recognized that it is practically impossible to incorporate teaching styles that will address the learning needs of all the students in a classroom, but suggested that small modifications to basic teaching styles would suffice to address the learning needs of most science students (Felder & Silverman, 1988; Felder & Spurlin, 2005).

In developing the ILS, Felder and Silverman separated learning into two main areas: Information gathering and information processing. Information gathering is accomplished through four main dimensions (Kolb, 1981):

- the sensory – the way by which information is gathered

- the modality – the method by which information is gathered
- the process – the method by which information is received
- the order – how information is processed

These areas of information gathering address the way in which information is received; however, once the information is received, the information is processed through five dimensions, which address how the brain gathers, processes, and retains this information. The five dimensions of information processing are based on Kolb's (1984) and Jung's (1971) theories of learning. They are:

- perception - how students perceive information
- reception - the preferred way students acquire information (visual, auditory or kinesthetic)
- organization - how the student organizes recently acquired information
- processing - how the student processes information
- understanding - how understanding takes place

Using the information gathering and the information-processing dimensions, Felder and Silverman theorized that learning occurs through five different but dichotomous modalities of learning:

- sensing – intuitive

Sensing learners are concrete and practical, while intuitive learners are innovative and conceptual.

- visual – verbal

Visual learners prefer pictures and diagrams, while verbal learners prefer written and spoken information.

- inductive – deductive

Inductive learners learn by classifying information from specific to general, while deductive learners learn by classifying information from the general to the specific.

- active – reflective

Active learners prefer learning by doing, while reflective learners prefer learning by thinking.

- sequential – global

Sequential learners learn by classifying things in a linear, orderly fashion, while global learners learn holistically by relating concepts to each other.

The ILS relates the learning dimensions: perception (sensory-intuitive), modality (visual-verbal), processing (active-reflective), and understanding (sequential-global), to the learning preference of the student by assigning a level on a sliding scale from -11 to +11 for each one of the components of the four dimensions discussed above.

This scale shows the learning preference on each modality, and illustrates that learning is a continuous process between modalities in which learning preference can be classified according to 32 different scales (2 styles in 5 categories = $2^5 = 32$). Felder and Soloman (1999) thoroughly discussed the fact that individual learning styles vary depending on time and circumstances, and therefore are not constant. This research was conducted on the premise that educational performance is influenced mainly by the learning style of the student (Claxton & Murrel, 1987; Claxton & Murell, 1988; Dunn & Dunn, 1979; Felder, 1993; Felder, 1996; Torres & Cano, 1994).

Barriers to Student Achievement

The United States is presently undergoing a major change in its demographics, a trend that is reflected in the very diverse student population in the post-secondary classrooms (Stern, 1994). The 2000 Bureau of Census, Current Population Survey estimated that by the year 2040, white, non-Hispanics would make up less than one-half of the school-aged population. The same survey also predicted that Hispanics would make up to 43% of the U.S. population by the year 2010. This change in demographics is raising awareness on the ability and effectiveness of the American school system in preparing students to fill the vacancies resulting from the retirement of the baby boomer generation.

According to the 2008-2009 edition of the Occupational Outlook Handbook (OOH) published by the Bureau of Labor Statistics, a large percentage of baby boomers (people born between 1946 and 1964) will retire between the years 2010 and 2020, creating a demand for qualified people to take over these positions. Nelson and Rogers (2004) reported that the increase in the diversity of the student population in the U.S. is raising awareness among educators on the need to introduce multicultural education at all levels of the American educational system.

A very important aspect of multicultural education in the classroom is the understanding of the effect that the learning style preference of the student has on his/her acquisition of knowledge, and consequently on his/her achievement in class. Understanding how a student learns allows the instructor to accommodate his/her teaching style to meet the learning needs of the student (Felder & Soloman, 1999). There are however barriers that students have to overcome to be able to take full advantage of a multicultural educational system. According to Helms (2003) “assumptions about who people are or are not, create limitations that allow ethnocentric and racist ideas to flourish and permeate” (p. 27). The quality of the teachers, the differences in economic status, and the ethnic biases perpetuate exclusion of certain segments of the student population from participation in educational programs. Oakes, Ormseth, Bell, and Camp (1990) stated that ”disproportionately African-American and Hispanic students, poor students, inner-city and rural school students are classified by schools as being low in academic ability and not likely to attend college” (p. 14). The ethnic, gender, and socio-economic status of the students in these school systems create an environment that encourages discrimination, low achievement, and poor performance.

Five factors are considered barriers for students in achieving an education to prepare them for future employment in sciences:

I. Judgment about their ability

A large percentage of students in America schools enter the educational system, as early as kindergarten, with learning difficulties and are placed in special education programs, low-achievement classes, slow track or remedial classes, factors that tend to slow their academic development (Slavin, 1987).

By the time these students reach high school they are underprepared in the basic science and general education areas, and are forced to go into non-academic, vocational education tracks (Rock, Braun, & Rosenbaum, 1985).

II. Access to science and mathematics

Access to science and mathematics classes and programs creates another barrier to students in most of the school systems in America (Oakes, Ormseth, Bell, & Camp;

1990). Quality of instruction and science curriculum in the middle and high schools are the most important factors in determining what students learn and how they perceive sciences in future educational choices (Goodlad, 1984). Goodlad reports that teachers, who are not subject area experts, are allowed to teach basic science education in the U.S. This trend is more prevalent in inner-city and rural schools, and expands from Kindergarten to high school. Oakes, Ormseth, Bell, and Camp (1990) report that inner-city and rural schools usually have large class size and fewer sections of science and math classes than their counterparts in more affluent neighborhoods. It has been recognized that students, who are not exposed to science and math in K-12, generally shy away from these subjects when they enroll in post-secondary institutions (Ekstrom, Goetz & Rock, 1988).

III. Access to qualified teachers in science and math

The 2006 NSB report indicates that students in the K-12 system who have access to teachers with knowledge and skills to teach science effectively are more likely to succeed in these areas, and therefore are more likely to choose careers in sciences. The NSB also reports that the number of science and math teachers in the K-12 system is down, and that this situation is likely to worsen with time. Stern (1994) reported that the lack of qualified science and math teachers is more prevalent in rural areas, urban districts, and high poverty areas, due mainly to difficulties in hiring and retaining well-qualified teachers. Stern also reported that the best-qualified teachers in science and math are generally found in predominantly white areas of high socio-economic status.

IV. Access to resources

Greenwald, Hedges, and Laine (1996) reported that inner city and rural schools, as well as schools in high poverty areas lack the most essential resources to teach science or math courses. Resources such as proper laboratory facilities, computer software and hardware, etc. are generally not available in these schools, thus hindering proper instruction in these areas (Wang, Haertel & Walberg, 1997).

The lack of resources in these schools is very often compounded by the lack of proper or current textbooks in the subject areas. This disparity in resources is directly proportional to the age of the school, with older schools, which are very often found in low income or inner city communities, having the least amount of resources, proper textbooks, or qualified teachers. This disparity is generally compounded at the high school level, where these resources are essential for the proper teaching of science, engineering, mathematics, and technology subjects.

Oakes, Ormseth, Bell, and Camp (1990) found that the ethnic composition and the socio-economic status of the students in the school also play a very important role in the availability of resources. Schools with large minority populations of lower socio-economic status had on average fewer resources than their counterparts in white, affluent neighborhoods.

V. Opportunities in the classroom

Jones (1984) reports a direct relationship between the science and math courses that students take in high school and the effect they have on the student performance in the same courses at the college and university level. If a high school does not offer classes in the basic sciences, such as chemistry, biology, physics, and math, the students graduating from this high school are less likely to enroll in these subject areas when they get to college or university. Courses that are considered gatekeepers or pre-requisites for a certain career exclude underprepared students trying to enroll in science or math education.

Chapter Summary

The 2006 National Science Board Science Indicators shows that there is a disparity in the teaching of sciences and math for inner-city and rural school students. This disparity is due mainly to lack of resources and underprepared teachers in the basic science fields. Research suggests that understanding how an individual learns and recognizing the individual's learning style preference, allows instructors to develop appropriate teaching techniques to address shortcomings in the basic education in science and mathematics at the post-secondary level. Felder and Silverman theorized that science and engineering students have a preferred learning style, and that only slight modifications in the present teaching philosophy are needed to address these learning styles, so that under prepared students are offered the opportunity to enroll and achieve in science. It is important to increase enrollment in sciences at the college and university level, because the U.S. will be facing a shortage of qualified scientists due to the retirement of a large segment of the Baby Boomer population currently conducting scientific research and development. The predicted shortage of qualified scientists is likely to jeopardize the U.S. position as a leader in research, development, and manufacturing in the world.

CHAPTER III

METHODOLOGY AND PROCEDURES

Introduction

This chapter discusses the methodology applied and the processes used to answer the research question guiding this study. Additionally, this chapter discusses the design, on which this research was based, the hypotheses that drove the study, the population from which the sample was drawn, the size of the sample, and the characteristics of the students who participated in the study. The variables of the study, and the types of instruments used to collect and analyze the data were also included in this discussion. The last section of the chapter includes a summary of the chapter.

Research Design

The purpose of this study was to determine the effect of the learning style preferences of students enrolled in introductory science classes at an urban college on their achievement as measured by the grade obtained at the end of the semester. The question that guided the study was: What effect does the learning style preference of students enrolled in introductory astronomy, biology, and chemistry classes have on achievement as measured by the grade obtained at the end of the course? This study was conducted to determine if a specific learning style is more likely to forecast success for students enrolled in introductory science classes.

For this purpose a quantitative (Creswell, 2003) approach was chosen to study the effect of the learning style preferences as determined by the Felder and Soloman Index of Learning Styles (ILS) as the independent variable, and the final grades obtained at the end of the semester as the dependent variable.

Creswell (2003) stated:

> A quantitative approach is one in which the investigator primarily uses post positivistic claims for developing knowledge (i.e., cause and effect thinking, reduction to specific variables and hypotheses and questions, use of measurement and observation, and the test of theories), employs strategies of inquiry such as experiments and surveys, and collects data on predetermined instruments that yield statistical data (p.18)

Population and Sample

The population in this study consisted of students enrolled in introductory astronomy, biology, and chemistry courses taught in two different campuses of an urban college. The sample was non-randomly selected from daytime classes taught by instructors who volunteered to participate in the study. The reason for choosing morning classes was that these classes are more likely to be populated by full-time students, who are recent high school graduates, and who plan to continue their education at a four-year institution (www.mdc.edu/IR).

The classes from which the sample was drawn were taught by instructors who use a combination of lecture-based presentations, in-class discussion groups, electronic delivery, and mentoring sessions in the form of Peer-led Team Learning. Their grading policies included in-class tests and quizzes, library and Internet research, and service learning components.

The classes chosen for this study were selected from all the morning classes offered by the college in the three subject areas included in the study. To choose the classes, the researcher listed all the offerings in introductory astronomy, biology, and chemistry on two campuses of the college and 12 of them were singled out as possibilities. The instructors of the 12 classes were approached by the researcher to inquire about the possibility of choosing their classes for participation in the study. Six of the 12 classes, three in each campus, were chosen. These classes were all morning classes taught between the hours of 9:00 AM and 12:00 NOON to avoid replication of student participation in the study.

The sample was selected as follows:

I. The researcher secured approval from the college administration to conduct the study

II. The instructors of the classes chosen for the study were contacted, and the researcher asked for 10 to 20 minutes at the beginning of one of their classes to introduce the study

III. The researcher introduced the study by reading to the class the information contained in Appendix A under pertinent information

IV. The students were encouraged to obtain a copy of the cover letter, which contained all the information regarding the study (Appendix B). Copies of the cover letter were left in a convenient location in the classroom, so that students interested in participating in the research could obtain a copy before leaving the classroom

V. The students who were willing to participate in the study were encouraged to contact the researcher via email to obtain a copy of the informed consent form (Appendix C), and a copy of the recruitment procedures (Appendix D)

VI. A copy of the consent form was sent to the participants via email. The consent form directed the participant to print a hard copy, sign it, and return it to the instructor of the class. All the signed forms were collected by the researcher and stored in a secured place

VII. After the participants returned the signed consent form, the researcher provided each student with instructions on how to proceed (Appendix E)

All participants were made aware that participation in this study was voluntary and that all the information provided would be kept confidential. The participants were instructed that declining to participate, or dropping out of the study would not have adverse consequences on their grade. A complete copy of the ILS by Felder and Soloman is included in Appendix F.

Data Collection Procedures

The data for the study were collected by an independent third party. The third party was a staff member in the chemistry department in one of the campuses where the study was conducted. The third party was not a classroom instructor and did not have any contact with the participants. The independent third party contacted the students who volunteered for the study via email before the study began to provide them with the Internet link (URL address) to the ILS so that students could log in. The third party also gave instructions to the participants on the proper way to forward the information gathered from the ILS for cataloging.

The data collected by the third party was coded using a five-digit randomly generated number that served as an identifier for each participant. The random code for each participant was generated using the random generation tool of

Microsoft Excel ®.The data were collected on two separate occasions. The first collection took place after the participants answered the 44 questions of Felder and Soloman ILS. The second collection took place at the end of the semester when the final grades for the class were collected from the instructors of the classes.

First Collection – The ILS server generated an immediate response after each participant completed the 44 questions of the questionnaire and submitted them for evaluation. The response provided the participant with an assessment of his/her learning style preference. The ILS response was generated in the form of an .html file, which the participants were instructed to save as a text file (.txt). A copy of the text file containing the assessment of the learning style preference of the participant was printed and forwarded to the third party, who coded the answers using a five-digit, randomly generated code assigned to each participant. The random number generating feature of Microsoft Excel ® was used to generate a five-digit number between 10000 and 99999, to make sure that there was no duplication of numbers in the participants' codes. The code used for this study did not contain information relating to name or identity of the participant to protect the anonymity of the data in the study. The first set of data was tabulated by code, learning style preference, and subject area by the third party using Microsoft Excel ® Spreadsheet.

Second Collection - At the end of the semester, the third party collected the grade for each participant from the instructor of the class. The grades were converted from letter grade to their corresponding numeric value using the standard conversion factor for the calculation of GPA, where an A=4, a B=3, a C= 2, a D= 1, and an F=0. The individual grades were entered into the original spreadsheet under the code assigned to each student during the first data collection, to complement the data required in the evaluation stage. A copy of the tabulated data was then sent to the researcher, who subjected it to Analysis of Variance (ANOVA) using the One-way ANOVA feature on the SPSS ® program.

Research Question and Hypotheses

The following research question was addressed by the study: What effect do the learning styles of the students enrolled in introductory science classes have on their achievement as measured by the grade obtained at the end of the semester?

The hypotheses that relate to the research questions were:

The Null, or statistical, hypotheses were:

H_{01}: There is no effect of the learning styles on achievement in biology classes

H_{02}: There is no effect of the learning styles on achievement in astronomy classes

H_{03}: There is no effect of the learning styles on achievement in chemistry classes

The research hypotheses were:

H_{A1}: There is an effect of learning styles on achievement in biology classes

H_{A2}: There is an effect of learning styles on achievement in astronomy classes

H_{A3}: There is an effect of learning styles on achievement in chemistry classes

Variables of the Study

The dependent or criterion variable for this study was the academic achievement in an introductory science class as determined by the grade obtained in the class at the end of the semester. Achievement was measured using an A-F scale with values between 4.0 for an A and 0.0 for an F. The independent variable in this study was the learning style preference of the student as assessed by the ILS.

Instrumentation

The learning style preference of the participants was assessed using the Felder - Soloman (2000) Index of Learning Styles (ILS). The ILS was developed by Felder and Soloman using five dimensions of learning which were based on Jung's (1971) psychological profiles of perception and Kolb's (1981) developmental theories for information processing. The Felder and Soloman dimensions of learning used to develop the ILS were:

- Perception - How students perceive information
- Reception - How students receive information, whether it is visual, auditory or kinesthetic
- Organizational - How students organize information
- Processing - How students process information
- Understanding - How understanding takes place

Organizing, the third dimension of the original ILS is based solely on inductive and deductive reasoning, which Felder and Soloman (2000) felt was part of the undergraduate curriculum, and therefore excluded it from the latest version of the ILS. Felder and Soloman state on the Web site: "the best method of teaching, at least below the graduate school level is induction, whether it is called problem-based learning, discovery learning, inquiry learning, or some variation on those themes (question 11).

The ILS is designed to process information in four dimensions of learning:

- seeing and hearing (reception)
- reflecting and acting (understanding)
- rational reasoning and intuitive reasoning (processing)

- analyzing and visualizing (perception)

The response generated by the ILS server after the student submits the answers to the 44 questions of the questionnaire assesses learning style preference based on four dimensions and classifies the participant in one of the following learning styles:

- Active and Reflective Learners - Active learners learn and retain better when they use the information, while reflective learners learn and retain information better when they think about it
- Sensing and Intuitive Learners - Sensing learners learn facts, while intuitive learners discover possibilities and relationships
- Visual and Verbal Learners - Visual learners learn and retain information when they see pictures, diagrams, time lines, etc., while verbal learners learn and retain information when they verbally discuss or write the information
- Sequential and Global Learners - Sequential learners learn and retain information when they approach the learning process linearly, i.e. from the specific to the universal, while global learners learn best when they go from the global to the specific

The ILS reports the results using a scale for each dimension and conveys the assessment according to the most dominant preference of the two modalities in each learning dimension. A copy of the Felder-Soloman Index of Learning Styles is included in Appendix E.

The reliability and validity of the ILS has been verified at length (Felder & Spurling, 2005; Litzinger, Lee, Wise, & Felder, 2005; Tate, 2003). Test-retest correlation coefficients, Cronbach alpha coefficients, and Pearson correlation coefficients done on the ILS over a period of time, indicate that the ILS is a very reliable instrument that can be used for the assessment of the learning style preferences of individual students. The validity of the ILS was tested by administering the inventory to engineering students over an extended period of time, with very consistent results. The ILS can also be used as a guide to help instructors design curriculum that addresses the learning needs of their students. Important, however, is the discussion of the information gathered in this study, which could possibly reveal additional information regarding learning styles and student achievement. Because of the non-random assignment of the students participating in the survey, generalization may not be possible.

Data Analysis Method

The data collected from the students in the sample was tabulated under learning style preference and grade using a Microsoft Excel ® spreadsheet. The tabulated data was then transferred to a Statistical Package for the Social Sciences (SPSS ®, version 18.00 for Windows) spreadsheet and was analyzed using the one-way ANOVA feature of the SPSS ® program. One-way ANOVA is a bivariate statistical approach to test for differences among two or more independent groups (Creswell, 2003; Moore & McCabe, 1999).

Chapter Summary

This chapter introduced the question that drove the study and the methodology used to design it. This chapter discusses the parameters used to define the population, the properties of the sample chosen for the study, the steps taken to collect and evaluate the data, and the findings from the statistical analysis.

CHAPTER IV

RESULTS

Introduction

The purpose of this study was to determine the effect of learning style preference of students enrolled in introductory science classes at an urban college on their achievement as measured by the grade obtained at the end of the semester. This research involved a quantitative analysis using One-way Analysis of Variance (One-way ANOVA) to measure the significance of the learning style preference (independent variable) on the grade obtained at the end of the semester by the participant (dependent variable). The grade obtained in the class was defined as a measure of proficiency in the area of science studied. This chapter discusses the population, the sample, the characteristics and size of the sample, the statistical analysis used to evaluate the data, and the findings from the study.

The Population

The population consisted of students enrolled in day-time introductory science classes in the areas of astronomy, biology, and chemistry at an urban college. The classes included in this study were not selected at random, but rather chosen for convenience from the over 250 lectures in science offered by the college in all of its eight campuses during the fall semester of the 2010-2011 academic year. Each class had a maximum enrollment of 45 students and was open for enrollment to all students in the college. The results of this study cannot be generalized due to the non-random nature of the sample; however, they can be used as a guideline to design further research in this area.

The Institutional Research data (http://www.mdc.edu/ir) gathered on these classes indicate that they were populated mainly by traditional college students, who were recent high school graduates enrolled on a full-time basis, and were planning to finish the last two years of their baccalaureate in a four-year university. A full-time student in the community college system of Florida is defined as a student enrolled in a minimum of twelve credits hours per semester (http://www.mdc.edu/ir). The classes chosen for this study were taught by full-time science faculty with similar teaching and class management styles, and comparable grading policies.

The Sample

The sample consisted of 277 students enrolled in six science classes taught in two campuses of the college. The sample distribution was: 144 students in biology (52% of the sample), 97 students in chemistry (35% of the sample), and 36 students in astronomy (13% of the sample). Table No. 1 shows the percent distribution of participants by subject area.

Table 1. **Distribution of sample by subject area**

Subject Area	No. of students	Percentage of Sample
Astronomy	36	13 %
Biology	144	52 %
Chemistry	97	35 %
Combined	277	100%

The Instrument

The instrument used for the assessment of the learning style preference of the participants was the Felder and Soloman (2000) Index of Learning Styles (ILS). Felder and Solomon originally developed the ILS to study the learning style preference of undergraduate engineering students at a four-year university. The original LSI was developed to include five learning style modalities: perception, reception, organization, processing, and understanding. In 2000 Felder and Soloman modified the LSI to exclude the organizational dimension of learning, and changed its name to the Index of Learning Styles (ILS). The ILS excludes the organizational dimension of learning because, according to Felder and Soloman (1999) induction-deduction is the preferred teaching modality in the undergraduate curriculum. In 2007 Felder stated:

> Barbara Soloman and I don't want instructors to be able to give our instrument to students, find that the students prefer deductive presentation, and use that result to justify continuing to use the traditional deductive instructional paradigm in their courses and curricula. We have therefore omitted this dimension from the instrument. (quest. 11).

The learning style preference component of the data used in this research was collected by asking the participants to answer the 44 questions of the Felder and Soloman ILS questionnaire (Appendix F). The ILS evaluates the learning style preference of an individual based on the following four dimensions of knowledge acquisition, as defined by Felder and Soloman (1999):

- Perception

Information can be perceived as either sequential or global (SEQ/GLO). Sequential learners learn better when information is presented to them in a linear manner, while global learners learn better when information is presented to them in a non-linear manner.

- Reception

Reception can be visual, auditory, or kinesthetic; however, Felder and Soloman assess reception as visual or verbal (VIS/VRB). Visual learners learn better when they see objects, pictures, or diagrams, while auditory learners learn better when they read written words or hear the words.

- Processing

Information is processed either actively or reflectively (ACT/REF). Active learners learn better when information is presented to them so that they can actively participate in the learning process, which is the case in Learning Communities (Tinto, 1993; Tinto, 1995; Tinto, 1997), while reflective learners learn better when information is presented to them in a manner that they must think and reflect about it, preferably alone.

- Understanding

Understanding involves either sensing or intuitive (SEN/INT) learning. Sensing learners learn best when presented with facts, and the means to use the information in practical ways, while intuitive learners learn best when presented with possibilities for innovation. Sensing learners tend to work more efficiently than intuitive learners, because they prefer to evaluate information wholly before committing to an answer.

Completion of the 44 questions of the ILS takes between ten and fifteen minutes. Soon after the student submits the answers to the 44 questions, the ILS server generates a response evaluating the student's learning style preference(s). The response from the ILS server is sent to the participant in the form of a .html file, which the participants were asked to save as a test file (.txt). The participants were then advised to print a hardcopy of the text file containing the ILS response and to send it to the third party for cataloging. The third party cataloged the responses using a numeric code assigned to each participant. The numeric code was generated using the random number generating function of Microsoft Excel ®. The third party was a non-teaching staff member of the college, who agreed to collect and tabulate the information.

The Data

The data used in the study were compiled from three sources: the individual response from the ILS server outlining the learning style preference, the grade that each student obtained at the end of the semester, and the course in which the student was enrolled. The learning style preference was cataloged in one of the four modalities of the ILS: perception, reception, processing, and understanding. The third party (gatekeeper) cataloged the participants' learning style preference and the course in which the student was enrolled under the numeric code assigned to each participant. The code assigned to each participant consisted of a five-digit, randomly generated number. This code was used to replace the student name and ID number, to preserve the anonymity of the participant and the confidentiality of the data.

The learning style preference of the participants was cataloged using a binary system where the number 1 indicated a positive learning style preference, while the number 0 indicated a negative learning style preference. The majority of the participants showed a learning style preference in only one modality; however some of the participants showed more than one learning style preference. Students showing more than one learning style preference were cataloged under the most dominant one.

At the end of the semester the instructors provided the gatekeeper (the third party) with the grades for each participant in the class. The gatekeeper converted the letter grade into a number using the standard conversion to calculate Grade Point Average (GPA), where an A=4, a B=3, a C=2, a D=1 and an F=0. After the grades were converted, they were entered into the spreadsheet under the numeric code assigned to each participant to complement the existing data, and a copy of the spreadsheet was sent to the researcher for evaluation using the Statistical Package for the Social Sciences (SPSS ®, version 18.00 for Windows).

The Statistical Evaluation of the Data

The question that guided this study was: What effect do the learning styles of students enrolled in introductory science classes have on their achievement as measured by the grade obtained at the end of the semester?

The Null, or statistical, hypotheses that guided this study were:

H_{01}: There is no effect of the learning style on achievement in astronomy

H_{02}: There is no effect of the learning style on achievement in biology

H_{03}: There is no effect of the learning style on achievement in chemistry

The research hypotheses for the study were as follows:

H_{A1}: There is an effect of learning styles on achievement in biology classes

H_{A2}: There is an effect of learning styles on achievement in astronomy classes

H_{A3}: There is an effect of learning styles on achievement in chemistry classes

To test the hypotheses, and to answer the original research question the data were subjected to statistical analysis using One-way Analysis of Variance (One-way ANOVA). One-way ANOVA is used to test the equality of three or more population means by analyzing sample variances (Stevens, 1990; Triola, 2011). For this research a probability value (significance) of less than 0.05 leads to the rejection of the null hypothesis of equal means ($p<.05$). One-way ANOVAs were used to test if the learning style preference (independent variable) had an effect on the grade obtained (dependent variable) at the end of the science classes included in the study.

Findings

Table No. 2 displays the frequency distribution of the sample by learning style preference in the three subject areas of the study. Table No. 2 also shows that the distribution of the learning style preference in the sample is bi-modal. The majority of the participants in the sample (105 or 38% of the sample) showed a learning style preference as visual/verbal (VIS/VRB) learners, while the second largest group of participants (77 or 28% of the sample) showed a learning style preference of sensing/intuitive (SEN/INT). The total number of students in these two modalities of learning style preferences was 183 or 66% of the sample.

Felder and Solomon (2000) classifies VIS/VRB learners in the information gathering category, and define them as individuals who gather information visually, auditory, or kinesthetic. These students learn best when the information is presented to then in the form of pictures, diagrams, flow charts, time lines, films, and demonstrations. Verbal learners gather information when it is presented to them as either written or verbal explanations. SEN/INT learners are classified by Felder and Solomon as reflecting and acting, meaning that they process information based on understanding. Sensing learners are defined by Felder and Solomon as persons who like facts; they solve problems using well established methods, they like detail work and are good at memorizing. Intuitive learners, on the other hand, prefer discovering possibilities and relationships. Intuitive learners like innovation and are very good at grasping new concepts.

Table 2. **Frequency distribution of sample by learning styles**

	ACT/REF	SEN/INT	VIS/VRB	SEQ/GLO
Astronomy	9	9	17	1
Biology	20	42	49	33
Chemistry	14	26	39	18
Combined	43	77	105	52

Table No. 3 shows the frequency distribution of the sample by grade in each class. The findings illustrated in this table show that 172 students in all classes (65% of the sample) got grades of A or B at the end of the semester. A comparison of the data illustrated in Table No. 2 with the data in Table No. 3 shows that there is a direct correlation between the number of students classified as VIS/VER and SEN/INT learners, and the frequency of students earning an A or a B at the end of the course.

Table 3. **Frequency distribution for the sample by grade**

Grades	A	B	C	D	F
Astronomy	9	12	7	5	3
Biology	55	37	22	19	11
Chemistry	36	23	14	12	12
Combined	100	72	43	36	26

Felder and Solomon stated that everyone learns more when information is presented both visually and verbally. The instructors teaching the classes included in the study used a variety of visual and verbal aids including PowerPoint ® slides, U-Tube ® films, in class demonstration, and written handouts to illustrate the most important topics of the curriculum. The data from table No. 2 and tableNo.3 show that the instructors used a teaching style that addressed the learning style preference of the majority of the students in the sample. It is also worth mentioning here that science classes are by nature designed to address SEN/INT learners, complementing the teaching/learning environment. These findings confirm Felder and Silverman (1988), Dunn, Griggs, and Dunn (1993), Felder and Silverman (1998), and Felder (2005) assertion that students learn better when they are taught in their preferred learning style, as a result of greater comprehension and retention of the material being taught.

Findings for Null Hypothesis 1 (H_{01})

Table No. 4 shows the results of the One-way ANOVA for the effect of learning style preferences of the students enrolled in astronomy on their achievement as measured by the grade obtained at the end of the semester.

Table 4. **One-way ANOVA of the learning style preference v. grade in astronomy**

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1.642	3	0.547	1.053	0.390
Within Groups	10.918	21	0.520		
Total	12.560	24			

The results of this One-way ANOVA indicate that there was no a significant effect of the learning style preference of students enrolled in introductory astronomy classes at the p>.05 level and their achievement as measured by the grade obtained at the end of the semester, for the three conditions [F (3, 21) = 1.053, p = 0.390]. These findings suggest that the learning style preference does not affect achievement in introductory astronomy classes. The data in this table fails to reject the first Null Hypothesis (H_{01}): There is no effect of learning style on achievement in astronomy classes.

Findings for Null Hypothesis 2 (H_{02})

Table No. 5 shows the results of the One-way ANOVA for the effect of learning style preferences of the students enrolled in biology on their achievement as measured by the grade obtained at the end of the semester.

Table 5. **One-way ANOVA of the learning style preference v. grade in biology**

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	0.854	3	0.285	0.523	0.668
Within Groups	50.651	93	0.545		
Total	51.505	96			

The results of this One-way ANOVA indicate that there was no a significant effect of the learning style preference of students enrolled in introductory biology classes at the $p>.05$ level and their achievement as measured by the grade obtained at the end of the semester, for the three conditions [F (3, 93) = 0.523, $p = 0.668$]. These findings suggest that the learning style preference does not affect achievement in introductory biology classes. The data in this table fails to reject the second Null Hypothesis (H_{02}): There is no effect of learning style on achievement in biology classes.

Findings for Null Hypothesis 3 (H_{03})

Table No. 6 shows the results of the One-way ANOVA for the effect of learning style preferences of the students enrolled in chemistry on their achievement as measured by the grade obtained at the end of the semester.

Table 6. **One-way ANOVA of the learning style preference v. grade in chemistry**

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	0.827	3	0.276	0.448	0.720
Within Groups	38.157	62	0.615		
Total	38.985	65			

The results of this One-way ANOVA indicate that there was no a significant effect of the learning style preference of students enrolled in introductory chemistry classes at the $p > .05$ level and their achievement as measured by the grade obtained at the end of the semester, for the three conditions [F (3, 62) = 0.448, $p = 0.720$]. These findings suggest that the learning style preference does not affect achievement in introductory chemistry classes. The data in this table fails to reject the third Null Hypothesis (H_{03}): There is no effect of learning style on achievement in chemistry classes.

Summary of Findings

Table No. 2 shows that the largest percentage of the participants (105 or 38% of the sample) in the three subject areas studied were visual/verbal learners, which mean that reception was their most prevalent mode of learning. The second largest percentage of participants (77 or 28% of the sample) was classified as sensorial/intuitive learners, meaning that their most prevalent mode of learning was perception. A review of the grade distribution in all classes (Table No. 3) shows that the percentage of the participants that completed the course with a grade of A or B (172 students or 62% of the sample) was comparable with the percentage of students represented in the two largest modalities of learning style preference. These results suggest that the teaching modalities used by the professors in the classrooms addressed the learning style preference of the participants, confirming Felder and Silverman (1998) theory that students learn better when their learning style preference is addressed by the professor in the classroom.

The findings in this study indicate that there is no significance between learning style preference of students enrolled in introductory science classes and their grade. These findings fail to reject all the Null Hypotheses of the Study:

- H_{01}: There is no effect of the learning style on achievement in astronomy
- H_{02}: There is no effect of the learning style on achievement in biology
- H_{03}: There is no effect of the learning style on achievement in chemistry

Chapter Summary

This chapter presented the findings of the statistical evaluation of the data collected when comparing the effect of the Learning Style Preference of students enrolled in science classes at an urban community college on their performance as defined by the grade obtained at the end of the semester. The population chosen for this study was students enrolled in introductory science classes in astronomy, biology, and chemistry. The learning style preference of the students comprising the sample was determined using the Felder and Soloman (2000) Index of Learning Styles (Appendix F), which classifies the learning style preference of individuals in one of four learning modalities: perception, reception, processing, and understanding.

One-way ANOVAs were performed to determine the significance of the learning style preference (independent variable) at p>.05 level on the grade obtained at the end of the semester in the three subject areas (dependent variable). The results of the One-way ANOVAs indicate that there is no effect of learning style preference at the on grades for students enrolled in introductory science classes. The results collected from the analysis of the data failed to reject the Null Hypotheses of the study.

CHAPTER V

DISCUSSION OF FINDINGS AND RECOMMENDATIONS

Introduction

The teaching of sciences, especially at the post-secondary level has historically been conducted as a lecture-driven delivery of information, with the instructor having full control of both, the topics and the timing (Felder & Silverman, 1988). Felder (2005) proposed that a better way to teach sciences is to deliver the information in a way that addresses the learning style preference of the majority of the students in the classroom. Kolb and Kolb (2005) suggested that a good way to address the learning style preference of the students in the classroom is by using experiential learning, which recommends that instructors use different methods of delivery to include as many learning styles as possible.

The purpose of this study was to determine if the learning style preference of the students in introductory science classes have an effect on their achievement as measured by the grade obtained at the end of the semester. Learning style preferences have been used to develop curriculum for the social sciences at the high school level (Anderson & Adams, 1992; Banks, 2003; Banks, 2006). A few studies have been conducted on the effect of learning style preference and achievement in the applied sciences at the undergraduate level (Torres & Cano, 1994; Felder & Silverman, 1998; Cano, 1999; Murphy, Gray, Straja, & Bogert, 2004) with positive results. If the learning style preference of the participants is determined to have an effect on achievement, curriculum can be developed to attract students to, and retain them in sciences.

Based on the review of the literature, the following null hypotheses were formulated in this study:

H_{01}: There is no effect of the learning style on achievement in astronomy classes

H_{02}: There is no effect of the learning style on achievement in biology classes

H_{03}: There is no effect of the learning style on achievement in chemistry classes

Summary of Findings

Table No. 2 shows that the largest percentage of the sample was visual/verbal learners, which mean that reception was their most prevalent mode of learning. The second largest percentage was made up of sensorial/intuitive learners, meaning that their most prevalent mode of learning was perception. A review of the grade distribution in the classes (Table No. 3) shows that the percentage of the participants who succeeded in the class with either an A, or a B was comparable to the percentages of the sample belonging to the two learning modalities prevalent in the classes. These results suggest that the teaching modalities used by the professors in the three areas of science studied addressed the learning style preferences of the students in their classes. Becker and Ravitz (2001) argued that there is a correlation between the use of technology by an instructor in the classroom and student-centered teaching styles.

A follow up with the instructors revealed that instruction in these classrooms was delivered as a combination of lecture-based presentation, in-class discussions, electronic delivery, and mentoring sessions. The high success rate, as determined by the grade distribution in the classes, and the bimodal distribution of the learning style preferences of the participants prompted the researcher to follow up on the methodology used to determine the final grade in the classes, because achievement in this study was defined as the grade obtained at the end of the course.

A second meeting with the instructors revealed that the grades in the classroom were a good indicator of basic knowledge in the subject matter, but may not have been a true measure of achievement, because the final grade in the classes was determined based on the following three parameters:

- The largest percent of the final grade (70%) was assigned to in-class multiple choice exams. Tests of this nature in an introductory, general education classroom are designed to test general knowledge of the subject area, and do not address depth of knowledge
- Library and Internet research made up another 20% of the final grade. This type of research was assigned to groups of four or five students on a particular area of the curriculum, and does not reflect the amount of work done by each student, but generated the same grade for all the students in the group
- In-class presentations on specific areas made up the final 10% of the final grade. These presentations were also done in small groups, but only one student represented the group during the presentation and may not reflect the depth of comprehension of the participants

Limitations of the Study

The limitations in this study were:

- The classes selected for this study were not randomly selected but chosen for convenience

- The classes selected do not include a cross section of all of the science courses taught at the college
- The classes selected do not represent a cross section of the individual teaching styles of the professors in these fields
- Participation in the study was strictly voluntary
- The grading policies of the instructors in the classes did not reflect the true depth of knowledge of the students in the subject area

Discussion of the Findings

The results obtained from the Analysis of Variance evaluation of the samples show that the probability value for all the One-way ANOVAs was higher than the significance level set for the study ($p>.05$). These results led the researcher to fail to reject the Null Hypotheses of the study: There is no significant effect of learning style preference on student achievement in introductory science classes.

The data collected in this study provided evidence that learning style preference of students enrolled in introductory science classes does not have a significant effect on achievement as measured by the grade attained by the student at the end of the semester; however the data gathered in tables No.2 and No. 3 indicate that the teaching style of the instructor in the class has an effect on student achievement. The classes chosen for this study were general education classes, and as such were taught using technology and learning community teaching techniques (Tinto, 1997). Introductory, general education science classes are developed to give students a basic working knowledge in sciences and are used to complete general education requirements, which complement the core courses required for area specific subjects. General education science classes are populated by students who are not majoring in science. The effect of learning style preference of students enrolled in introductory science classes on achievement may not therefore be a reliable measure of the student depth of knowledge in science.

Recommendations for Further Research

This study focused on the effect of learning style preference on achievement in introductory science classes. The findings from this study indicate that there is not an effect of learning style preference on achievement in introductory science classes, therefore this study could be replicated using a larger sample comprised of students enrolled in regular science classes. Regular science classes are populated by students majoring in science; however the study could be broadened to include classes in the social sciences and the liberal arts, to determine if learning style preferences are significant on achievement in all areas of the curriculum. Future studies could include classrooms with different teaching styles, from the traditional lecture format to the fully web-based format.

Achievement is defined as a true measure of the depth of knowledge in a specific area. Achievement can therefore be assessed using the standardized test developed by the different professional societies, because these tests have been developed to assess subject-specific knowledge of affiliate-members at the undergraduate level. The American Chemical Society (ACS), for example, developed tests to assess knowledge in chemistry at the high school, college, and university level (http://chemexams.chem.iastate.edu); however, similar tests have been developed for physics (http://www.aps.programs.education/index.cfm), astronomy (http://www.aas.org/education/EducatorResources.php), psychology (http://www.apa.org/monito/dec02/assesing.aspx), etc. These standardized tests can be used to assess student knowledge in natural sciences, social sciences, liberal arts, and all other areas of the curriculum at the post-secondary level.

This study could also be replicated using different learning style assessment instruments, such as the Myers-Briggs Type indicator (Myers-Briggs, 1980), which explores connections between personality, temperament, learning style, and career choice. Another learning style inventory that could be used to assess learning style preference is the VARK (visual, aural, reading/writing, and kinesthetic), which can be found at http://www.vark-learn.com/english/index.asp. These are two of the many learning style inventories available in the literature that can be used to assess the learning style preference of students in all areas of the curriculum.

A qualitative study might also be conducted on the experiences of the instructor in both sciences and social sciences for classes in which the teaching style of the instructor is altered to accommodate the learning style preference of the students.

Chapter Summary

The purpose of this study was to determine the effect of learning style preference on achievement in introductory science classes. The population for the study was students enrolled in introductory astronomy, biology, and chemistry classes, which produced a sample of 277 participants. The framework that guided this study was the Experiential Learning Theory developed by Kolb in 1984, which served as the basis for the Index of Learning Styles (ILS) developed by Felder and Soloman (2000). The Felder and Soloman ILS was the instrument used for the evaluation of the learning style preference of the participants. One-way ANOVAs of the learning style preference of the participants (independent variable) were run against the grade obtained by the participant (dependent variable) at the end of the class, to determine if there was any significant effect of learning style preference on achievement. The results from this study indicated that there was no significant effect of learning style on achievement ($p > .05$), thus causing the researcher to fail to reject the Null Hypotheses of the study. This chapter also outlined the limitations of the study and concluded with recommendations for further studies.

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Appendix A

Pertinent Information

(This flyer is to be read to the class by the researcher. Hard copies of the cover letter will be placed on an empty student desk next to the exit door, so that students interested in participating in the study can obtain a copy of the cover letter upon exiting the classroom)

I am conducting a study designed to identify any correlation between the learning style preferences of students in your classroom, and achievement as measured by the final grade obtained at the end of the semester.

The title of the study is: ***A Comparison of Four Learning Styles on College Science Achievement***

Your consent to be a research participant in this study is strictly voluntary and should you decline to participate or should you choose to drop out at any time during the study, there will be no adverse effects on your grades in the class.

Your contribution to this study involves answering 44 questions in an on-line survey questionnaire called the Index of Learning Styles (ILS) that identifies your learning style preference. Completing the questionnaire will take between 10 and 20 minutes of your time. The questionnaire will provide you with the evaluation of your learning style preference, which will be send to you as a reply from the ILS server immediately upon completing the questionnaire.

If you are interested in participating in the study, please take a copy of the cover letter found by the exit door. If you have any questions please contact me via email at

jesalina@bellsouth.net

or by phone at (305) 237-3087, and I'll be more than happy to answer any questions you may have regarding this research, or the Inventory of Learning Styles. *You may also contact my advisor, Dr. Edward Bernstein, at (305) 899-3702, or the Institutional Review Board point of contact at Barry University, Ms. Barbara Cook, at (305) 899-3020.*

Appendix B
Barry University - Cover Letter

Dear Research Participant:

Your participation in a research project is requested. The title of the study is: A Comparison of Four Learning Styles on College Science Achievement. The research is being conducted by Jorge E. Salinas, a student in the School of Education, Department of Higher Education and Leadership at Barry University, and is seeking information that will be useful in the field of science education. The aims of the research are to compare the learning style preferences of science students with their achievement in class, information that can aid in the development of teaching methods that can be used to encourage enrollment and retention in science classes. In accordance with these aims, the following procedures will be used: The participants in this research will respond to an on-line Index of Learning Styles (ILS) questionnaire that will assess the learning style preference of the participant. The responses from the ILS will then be analyzed against the grade achieved by the participant at the end of the semester to determine if there is a correlation between learning style preference and achievement in class. We anticipate the number of participants to be a maximum of 200. This task will take between 10 and 20 minutes or your time.

Your consent to be a research participant is strictly voluntary and should you decline to participate or should you choose to drop out at any time during the study, there will be no adverse effects on your grades in the class.

There are no risks to you; however, there is an indirect benefit to you and it is namely to help you identify your learning style preference, which you can use to optimize your learning experience in the classroom.

As a research participant, information you provide will be kept anonymous, that is, no names, or other identifiers will be collected on any of the instruments used. Data will be kept in a locked file in the researcher's office for a minimum of one year after the study has been concluded. By completing and returning the ILS Survey, you have shown your agreement to participate in the study. To get the URL address of the ILS please contact the researcher at:

jesalina@bellsouth.net

If you have any questions or concerns regarding the study or your participation in the study, you may contact me, Jorge E. Salinas, at (305) 237-3087, my supervisor, Dr. Edward Bernstein, at (305) 899-3861, or the Institutional Review Board point of contact, Barbara Cook, at (305) 899-3020.

Thank you for your participation.

Sincerely,

Jorge E. Salinas

Appendix C
Informed Consent Form

Your participation in a research project is requested. The title of the study is: A Comparison of Four Learning Styles on College Science Achievement. The research is being conducted by Jorge E. Salinas, a student in the School of Education, Department of Higher Education and Leadership at Barry University, and is seeking information that will be useful in the field of science education for science students. The aims of the research are to correlate the learning style preferences of science students with their achievement in class, information that can aid in the development of teaching methods that can be used to encourage enrollment and retention in science classes. In accordance with these aims, the following procedures will be used: The participants in this research will respond to an on-line Index of Learning Styles (ILS) questionnaire that will assess the learning style preference of the participant. The responses from the ILS will then be analyzed against the grade achieved by the participant at the end of the semester to determine if there is a correlation between learning style preference and achievement in class. We anticipate the number of participants to be a maximum of 200.

If you decide to participate in this research, you will be asked to print and sign this form, and to return the signed form to your instructor. The next step is to answer the 44 questions of the ILS questionnaire. This task will take between 10 and 20 minutes or your time.

Your consent to be a research participant is strictly voluntary and should you decline to participate or should you choose to drop out at any time during the study, there will be no adverse effects on your grades in the class.

There are no risks to you; however, there is an indirect benefit to you and it is namely to determine your learning style preference which you can use to optimize your learning experience in the classroom.

As a research participant, information you provide will be held in confidence to the extent permitted by law. Any published results of the research will refer to group averages only and no names will be used in the study. Data will be kept in a locked file in the researcher's office. Your signed consent form will be kept separate from the data. All data will be destroyed one year after the termination of the study. If you agree to participate in this study, please print this form, sign it, and turn it in to your instructor.

If you have any questions or concerns regarding the study or your participation in the study, you may contact me, Jorge E. Salinas, at (305) 237-3087, my supervisor, Dr. Edward Bernstein, at (305) 899-3861, or the Institutional Review Board point of contact, Barbara Cook, at (305)899-3020. If you are satisfied with the information provided and are willing to participate in this research, please signify your consent by signing this consent form.

Voluntary Consent

I acknowledge that I have been informed of the nature and purposes of this experiment by Jorge E. Salinas and that I have read and understand the information presented above, and that I have received a copy of this form for my records. I give my voluntary consent to participate in this experiment.

______________________ __________
Signature of Participant *Date*

______________________ __________
Researcher *Date*

Appendix D

Recruitment Procedures

The participants in this study will be selected based on their availability and willingness to respond to the 44 questions of the Felder –Solomon Inventory of Learning Styles (ILS), and must satisfy the research criteria rules. Completing the questionnaire will take between ten and twenty minutes, and the participant will get an immediate response with his/her learning style preference.

The maximum number of participants will be 200 students enrolled in six science classes at an urban Community College. The science classes will be selected from the over the 100 science classes offered by the College every semester in the two campuses chosen for the research. The classes selected as the sample for this study will be two classes in Astronomy, two classes in Biology, and two classes in Chemistry. These classes will be selected from the block of classes offered in the morning and taught by professors with similar teaching styles and comparable grading policies.

The following procedure will be used to recruit the population for the study:

a) The researcher will select six classes (two in each area) to fit the criteria of the study
b) the researcher will contact each of the professors teaching the selected classes to explain to them the nature of the research and to ask for their cooperation
c) if the instructor agrees to participate, the researcher will then visit each of the classes, to explain to the students the nature of the research and depth of their involvement if they agree to participate. The researcher will at this point stress the fact that participation is voluntary, and that non-participation will bear no adverse consequences on the participant. The researcher will also make clear to the class that all participants will remain anonymous (Appendix B – Pertinent Information)
d) Copies of the Barry University Cover Letter (Appendix C) will be made available to the participants, to officially provide the participants with all the pertinent information about the research.
e) after the participants review the cover letter and agree to participate, they will be provided with a copy of the consent form (Appendix D), which they are instructed to sign and return to their instructor
f) once the consent form is signed, the instructor will provide the participants with the URL for the Index of Learning Styles (ILS) questionnaire, as well as with instructions on how to follow up (Appendix E – Follow Up))
g) follow-up instructions include the name and email address of the third party (gate keeper) in-charge of gathering and cataloging the responses from the students. The third party will not be involved in the evaluation of the results, to insure anonymity of the participants

Students will also have the option not to participate in the study. The consent form (Appendix D). clearly states that non-participation is a viable option. If the student opts not to participate in the study, or drops out of the study after he/she has signed the consent form, he/she will simply not send the ILS response for evaluation.

Appendix E

Follow Up

Thank You for agreeing to participate in the study.

The Index of Learning Styles is found at:

http://www.engr.ncsu.edu/learningstyles/ilsweb.html

Immediately upon completion of the survey, you will receive an answer describing your learning style preference. Please save the answer on the desktop of your computer. The file will be automatically saved as a .html file.

Forward a copy of this file to Ms. Dianne McKinney at dmckinne@mdc.edu. Ms. McKinney will serve as the gatekeeper of the information, and as such will catalog the information and assign your file an alphanumeric code to ensure privacy, confidentiality, and anonymity.

If you decide not to participate in the study, please do not forward the file. Your decision not to participate in the study will have no negative consequences and will not affect your grade in the class.

If you have any questions regarding the evaluation of your learning style preference, please do not hesitate to contact me and I will explain the results to the best of my ability. Thank you again for agreeing to participate.

Jorge E. Salinas

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Appendix F

Index of Learning Styles Questionnaire

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First-Year College
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Raleigh, North Carolina 27695

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Directions

Please provide us with your full name. Your name will be printed on the information that is returned to you.

Full Name

For each of the 44 questions below select either "a" or "b" to indicate your answer. Please choose only one answer for each question. If both "a" and "b" seem to apply to you, choose the one that applies more frequently. When you are finished selecting answers to each question please select the submit button at the end of the form.

1. I understand something better after I
   - **(a)** try it out.
   - **(b)** think it through.
2. I would rather be considered
   - **(a)** realistic.
   - **(b)** innovative.
3. When I think about what I did yesterday, I am most likely to get
   - **(a)** a picture.

- **(b)** words.

4. I tend to
   - **(a)** understand details of a subject but may be fuzzy about its overall structure.
   - **(b)** understand the overall structure but may be fuzzy about details.
5. When I am learning something new, it helps me to
   - **(a)** talk about it.
   - **(b)** think about it.
6. If I were a teacher, I would rather teach a course
   - **(a)** that deals with facts and real life situations.
   - **(b)** that deals with ideas and theories.
7. I prefer to get new information in
   - **(a)** pictures, diagrams, graphs, or maps.
   - **(b)** written directions or verbal information.
8. Once I understand
   - **(a)** all the parts, I understand the whole thing.
   - **(b)** the whole thing, I see how the parts fit.
9. In a study group working on difficult material, I am more likely to
   - **(a)** jump in and contribute ideas.
   - **(b)** sit back and listen.
10. I find it easier
    - **(a)** to learn facts.
    - **(b)** to learn concepts.
11. In a book with lots of pictures and charts, I am likely to
    - **(a)** look over the pictures and charts carefully.
    - **(b)** focus on the written text.
12. When I solve math problems
    - **(a)** I usually work my way to the solutions one step at a time.
    - **(b)** I often just see the solutions but then have to struggle to figure out the steps to get to them.
13. In classes I have taken
    - **(a)** I have usually gotten to know many of the students.

- **(b)** I have rarely gotten to know many of the students.

14. In reading nonfiction, I prefer
    - **(a)** something that teaches me new facts or tells me how to do something.
    - **(b)** something that gives me new ideas to think about.
15. I like teachers
    - **(a)** who put a lot of diagrams on the board.
    - **(b)** who spend a lot of time explaining.
16. When I'm analyzing a story or a novel
    - **(a)** I think of the incidents and try to put them together to figure out the themes.
    - **(b)** I just know what the themes are when I finish reading and then I have to go back and find the incidents that demonstrate them.
17. When I start a homework problem, I am more likely to
    - **(a)** start working on the solution immediately.
    - **(b)** try to fully understand the problem first.
18. I prefer the idea of
    - **(a)** certainty.
    - **(b)** theory.
19. I remember best
    - **(a)** what I see.
    - **(b)** what I hear.
20. It is more important to me that an instructor
    - **(a)** lay out the material in clear sequential steps.
    - **(b)** give me an overall picture and relate the material to other subjects.
21. I prefer to study
    - **(a)** in a study group.
    - **(b)** alone.
22. I am more likely to be considered
    - **(a)** careful about the details of my work.
    - **(b)** creative about how to do my work.
23. When I get directions to a new place, I prefer
    - **(a)** a map.

- **(b)** written instructions.

24. I learn
    - **(a)** at a fairly regular pace. If I study hard, I'll "get it."
    - **(b)** in fits and starts. I'll be totally confused and then suddenly it all "clicks."
25. I would rather first
    - **(a)** try things out.
    - **(b)** think about how I'm going to do it.
26. When I am reading for enjoyment, I like writers to
    - **(a)** clearly say what they mean.
    - **(b)** say things in creative, interesting ways.
27. When I see a diagram or sketch in class, I am most likely to remember
    - **(a)** the picture.
    - **(b)** what the instructor said about it.
28. When considering a body of information, I am more likely to
    - **(a)** focus on details and miss the big picture.
    - **(b)** try to understand the big picture before getting into the details.
29. I more easily remember
    - **(a)** something I have done.
    - **(b)** something I have thought a lot about.
30. When I have to perform a task, I prefer to
    - **(a)** master one way of doing it.
    - **(b)** come up with new ways of doing it.
31. When someone is showing me data, I prefer
    - **(a)** charts or graphs.
    - **(b)** text summarizing the results.
32. When writing a paper, I am more likely to
    - **(a)** work on (think about or write) the beginning of the paper and progress forward.
    - **(b)** work on (think about or write) different parts of the paper and then order them.
33. When I have to work on a group project, I first want to
    - **(a)** have "group brainstorming" where everyone

contributes ideas.

- **(b)** brainstorm individually and then come together as a group to compare ideas.

34. I consider it higher praise to call someone
    - **(a)** sensible.
    - **(b)** imaginative.
35. When I meet people at a party, I am more likely to remember
    - **(a)** what they looked like.
    - **(b)** what they said about themselves.
36. When I am learning a new subject, I prefer to
    - **(a)** stay focused on that subject, learning as much about it as I can.
    - **(b)** try to make connections between that subject and related subjects.
37. I am more likely to be considered
    - **(a)** outgoing.
    - **(b)** reserved.
38. I prefer courses that emphasize
    - **(a)** concrete material (facts, data).
    - **(b)** abstract material (concepts, theories).
39. For entertainment, I would rather
    - **(a)** watch television.
    - **(b)** read a book.
40. Some teachers start their lectures with an outline of what they will cover. Such outlines are
    - **(a)** somewhat helpful to me.
    - **(b)** very helpful to me.
41. The idea of doing homework in groups, with one grade for the entire group,
    - **(a)** appeals to me.
    - **(b)** does not appeal to me.
42. When I am doing long calculations,
    - **(a)** I tend to repeat all my steps and check my work carefully.
    - **(b)** I find checking my work tiresome and have to force myself to do it.

43. I tend to picture places I have been

- **(a)** easily and fairly accurately.
- **(b)** with difficulty and without much detail.

44. When solving problems in a group, I would be more likely to

- **(a)** think of the steps in the solution process.
- **(b)** think of possible consequences or applications of the solution in a wide range of areas.

When you have completed filling out the above form please click on the Submit button below. Your results will be returned to you. If you are not satisified with your answers above please click on Reset to clear the form.

Submit Reset

Dr. Richard Felder, felder@ncsu.edu