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AN INVESTIGATION OF THE STUDENT USE OF TACTUAL LEARNING-STYLE
PREFERENCE TECHNIQUES AND STUDENT SELF-PERCEPTION

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A Dissertation

Submitted in Partial Fulfillment of the

Requirements for the Degree of

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in the

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at

Western Connecticut State University

2015

AN INVESTIGATION OF THE STUDENT USE OF TACTUAL LEARNING-STYLE
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Abstract

Students across the United States are routinely administered state assessments to measure academic progress in the grade level they have been assigned. These tests have become the measure of a district or school's ability to meet Adequate Yearly Progress (AYP). Many students are not able to attain the expected level of proficiency. In 2011 in rural high-need school districts in New York State, 43% of third through fifth grade students did not make AYP in mathematics (non-AYP students; New York State Education Department, 2011). The Common Core Standards have been implemented to ensure that students graduating from high school are prepared to succeed in college or a career (Common Core, 2014). Students who are unable to show proficiency in elementary school are at risk of dropping out of school prior to graduation.

The purpose of this exploratory study was to compare the learning-style preferences of fifth grade students who achieved adequate yearly progress in mathematics and those who did not achieve AYP. The study investigated non-AYP students' use of tactual learning-style preference strategies and the perceptions of these students in the use of tactual materials. Fifth grade students in this study were administered the Learning Style: Clue to You! (LSCY), a learning-style assessment used to determine preferences and strengths for learning. Assessment data were used to determine the similarities and differences between AYP and non-AYP students with a Chi-square Crosstabulation test. The learning-style elements for auditory learning and time of day revealed significance between the groups.

Further analyses were completed with a Chi-square Goodness of Fit test to determine the learning-style preferences of non-AYP fifth grade students. Eleven of the 22 elements revealed significance within the group in the strands related to environmental, emotional, sociological, and physiological preferences.

Prescriptive training was provided to a select group of non-AYP students in using learning strategies that matched their tactual learning-style preference. Qualitative data were collected through the use of student portfolios, interviews, a focus group, and student self-reflections. Semi-structured interviews and a focus group were conducted to explore the use of the learning-style profile and the application of tactual strategies with mathematics. These data were examined to determine a better understanding of the connection between learning styles and students' perceptions. Analysis of the qualitative data revealed that students were able to identify preferences related to their learning style and students had an increased awareness of themselves as a learner.

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APPROVAL PAGE



*School of Professional Studies
Department of Education and Educational Psychology
Doctor of Education in Instructional Leadership*

Doctor of Education Dissertation

AN INVESTIGATION OF THE STUDENT USE OF TACTUAL LEARNING-STYLE
PREFERENCE TECHNIQUES AND STUDENT SELF-PERCEPTION

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I would like to acknowledge the students who participated in this study. They enthusiastically took on their roles. Through them I was able to understand and explain their experiences of how learning styles helped them learn and how it can help other students learn. I am grateful to them all.

Dedication

My dissertation is dedicated to my children, Francis and Kaitlin. You have been the quiet enduring force that consistently supported me throughout this process. I admire the adults you have become and you mean everything to me.

I also dedicate this work to the students who made this possible. I could never have anticipated how willingly each of you participated in the study. Our experiences together were more than I expected. I will always be grateful.

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CHAPTER ONE: INTRODUCTION TO THE STUDY

Since the 1960s, researchers have been exploring and reporting on the use of learning-style based instruction. Published research articles have reported the significant successes of students when matched with their learning preferences and also showed that students with mismatched instruction have difficulty with academic achievement (Dunn, Honigsfeld, & Shea Doolan, 2009). Lovelace (2005), in her meta-analysis of the Dunn and Dunn Learning-Style Model, reported that the results of over 7,000 students showed improvement in academic achievement with the identification of student learning-style preferences combined with instruction that was complementary to the student.

Teachers are expected to adapt materials, modify curriculum, and accommodate for the instructional needs of all their students. An elementary teacher may have contact with as many as 25 students during the school day, and be responsible for preparing and teaching five different subjects. Teachers are challenged to meet the needs of their students, and without a valid and reliable instrument, are unaware of students' learning styles. Today's teachers have not been trained to create learning environments and provide instruction that match the individual learning preferences of the students. Students who have a primary perceptual strength of being taught with tactual materials are often overlooked. Mismatched instruction can precipitate behaviors that are disruptive to the learning environment (Shea Doolan & Honigsfeld, 2000).

Learning Style assessment and implementation of responsive learning-style strategies can facilitate "the way in which *each* learner begins to concentrate on, process, and retain new and difficult information" (Dunn & Dunn, 1992, p. 2). Teacher observations of students' learning styles can be inaccurate, and without identification, educators are unable to provide conducive environments and implement effectively appropriate matched instruction. When students'

instruction is matched with their personal learning style, their perceptions of themselves improved along with the level of academic achievement. Students have reported that knowledge of their learning-style preferences provided an understanding of the way they learned which empowered them to attempt to reach higher goals than in the past (Dunn et al., 2009; Fine, 2003).

Statement of the Problem

In 2011, in rural school districts in New York State, 42% of fifth grade students were not proficient in mathematics (New York State Education Department, 2011). In the district where the research was conducted, 50% of the fifth grade cohort, or 54 out of the 108 students scored below the New York State proficiency level in mathematics. Specifically, the district has not been able to meet the needs of two subgroups: Students with Disabilities and Economically Disadvantaged Students, both predictors of potential dropouts. Analyses of the state data resulted in evaluating the mathematics instruction and materials. Additional instructional class time was extended, and computer assisted software was provided. These program changes did not produce increased achievement in mathematics.

Special Education and underperforming students have a tendency to be similar in their learning-style preferences, but considerably different from high achievers and gifted students (Braio, Beasley, Dunn, Quinn, & Buchanan, 1997). Mismatched instruction and learning style can frustrate a student and impede the learning process (Shea Doolan & Honigsfeld, 2000). Identifying students' learning-style strengths and using them for instruction will help students succeed with grade level content and improve their performance on standardized tests. Dunn and Dunn (2005) reported that tactical resources were found to be particularly beneficial for students who were underperforming in grades kindergarten through high school. They found that when

tactual materials were matched with learning-style preferences and were used with elementary school children, significantly more material could be learned. It has been well researched and documented that low-performing, tactual students become more engaged in their learning by using small motor movements with tactual resources that require manipulation (Braio et al., 1997; Dunn & Dunn, 2005; Fine, 2003; Hongisfeld & Dunn, 2009).

Therefore, this mixed method study explored the learning-style similarities and differences between fifth grade students who were achieving adequate yearly progress (AYP) in mathematics and students who were not achieving adequate yearly progress (non-AYP). The specific learning-style preferences of the non-AYP were also examined. The perceptions of non-AYP students and their use of tactual learning-style strategies were explored in the qualitative portion of the study.

Potential Benefits of Research

A learning-style assessment documents a child's preference for learning. Teachers make inaccurate assumptions of student learning styles and therefore are unable to match appropriate instruction for their students. Obtaining learning style information on students who are having difficulty in achieving in mathematics can be compared to their successful peers. The host district will be able to make researched-based decisions on the implementation of the responsive learning-style strategies for both groups. The results may provide valuable information concerning the achievement of non-AYP students when taught through their learning-style preferences.

Through instruction in the use of tactual resources, students will be enabled to learn grade level material and advocate for themselves after learning about their individual learning style. These students will be exposed to life-long learning strategies that have the potential to be

empowering through personal motivation or success and self-regulation. Through this research, the students can develop a stronger attachment to school by learning and mastering grade level content through their preferred tactual learning style. Students who and utilize these strategies may see an increase in their achievement and be able to demonstrate the acquisition of new learning.

Learning style implementation for underachieving tactual students will provide the participants the opportunity to learn new and difficult information that teachers deemed too advanced for this population. Providing appropriate training and working with matched instructional strategies for tactual learners may facilitate self-directed learning and improved academic achievement in mathematics. Students in previously conducted studies found that students who were matched with their learning-style preferences were successful in their academic achievement (Schiering & Dunn, 2001).

Underachievers and potential dropouts are a significant issue for many school districts. The gravity to implement the current Common Core State Standards (www.corestandards.org) and to prepare all students to be college and career ready has been put on the shoulders of classroom teachers. The results of this study echo documentation on the use of learning-style strategies that have had a positive effect on student achievement. District administrators and teachers can reexamine the benefits that learning-style strategies can provide in order to create environments and resources that make learning opportunities accessible to all students.

Definition of Terms

The following terms are relevant to this research study.

1. *Adequate Yearly Progress* (APY) indicates that a district or school has made satisfactory progress toward attaining proficiency for all students. Students achieving

Level 3 or 4 on the state assessment are considered proficient (New York State Education Department, 2012).

2. *Economically Disadvantaged Students* live in a household that has income below the poverty guideline as determined by the United States Department of Health and Human Services (New York State Education Department, 2011).
3. “*Learning Style* is the way in which *each* learner begins to concentrate on, process, and retain new and difficult information” (Dunn & Dunn, 1992, p. 2).
4. *Perception* includes “the processes that organize information in the sensory image and interpret it as having been produced by properties of objects or events in the external, three-dimensional world (American Psychological Association, 2014, Tab 16).
5. *Student with a Disability* has met the requirements of classification because of a mental, physical, or emotional reason as defined by the New York State Education Law, section 4401(1). They receive special services or participate in programs based on their specific disability (New York State Education Department - Special Education, 2011).
6. *Tactual Learner* is a student who learns through touching and manipulating resources (Dunn, 2001).
7. *Underachievers* are students who show a discrepancy between their school performance and their actual ability as indicated by standardized testing (United States Department of Education, 2014).
8. “*Universal Design for Learning* is a set of principles for curriculum that give all individuals equal opportunities to learn” (National Center on Universal Design for Learning, 2011, p. 1).

Research Questions

This study addressed the following questions:

Research Question One: Are there differences between the learning-style preferences of fifth grade students not achieving adequate yearly progress and the learning-style preferences of fifth grade students achieving adequate yearly progress in mathematics?

Hypothesis: There will be differences between the learning-style preferences of fifth grade students not achieving adequate yearly progress and the learning-style preferences of fifth grade students achieving adequate yearly progress in mathematics.

Research Question Two: Are there common learning-style preferences among fifth grade students who are not achieving adequate yearly progress in mathematics?

Hypothesis: There are common learning-style preferences among fifth grade students who are not achieving adequate yearly progress in mathematics.

Research Question Three: In what ways do tactually-preferenced, non-AYP fifth grade students use their learning-style profiles to design instructional strategies that facilitate learning?

Research Question Four: What are the perceptions of tactually-preferenced, non-AYP fifth grade students when using tactual learning-style strategies?

Related Literature to Support Rationale

In numerous studies, evidence has been provided that use of identified learning-style preferences facilitated student academic achievement, improved students' attitudes toward learning, and increased positive behavior (Dunn & Dunn, 1992, pp. 2-3). The Dunns reported that these preferences "make the identical instructional environments, methods, and resources effective for some learners and ineffective for others" (Lovelace, 2005, p. 177). Lovelace explains that the combination of preferences that affect and individual's learning style can vary,

making students learning in identical environments, with the same methods, and resources ineffective (p. 177).

Underachievers have been found to be tactual/kinesthetic learners and can be confused when taught auditorially, which is common in most traditional classrooms. According to Dunn and Dunn, “Perceptual preferences may be the most important aspect of learning style”, and “either enable or prevent individuals from achieving easily” (as cited in Lovelace, 2005, p. 177). Their theory, supported by extensive research, showed that when students were taught with complementary methods that matched their individual characteristics, they became more motivated and were able to demonstrate better academic achievement (Lovelace, 2005).

Researchers have tested this theory with many sub-groups of underachievers such as Students with Disabilities, gifted underachievers, students diagnosed with ADHD, and remedial students (Braio et al., 1997; Brand, Dunn, & Greb, 2002, Fine, 2003; Nunn, 1995; Rayneri, Gerber, & Wiley, 2003). The research documents that students who do not learn conventionally are able to be successful when their learning styles are identified (Brand et al., 2002; Lovelace, 2005). Based on the research presented, it can be concluded that individuals have unique learning styles and the sub-groups often identified as underachievers, also have unique learning styles that often do not match the instructional methods of a typical traditional classroom.

Overview of the Methodology

The study was conducted using an exploratory sequential mixed method design. The study took place in a small, rural school district in New York State with a population of 1,560 students. The elementary school in the study had 359 students. The district was under focused review for not achieving state expectations for academic performance in ELA and Mathematics for Students with Disabilities and Economically Disadvantaged students. The fifth grade population included

108 students with 54 AYP students and 54 non-AYP students in mathematics. Students' learning styles were assessed using the Learning Style: Clue to You! (LSCY; Burke & Dunn, 1998). The learning-style preferences of the groups were compared, and the specific learning-style preferences were identified in the non-AYP group. Six out of 10 tactually preferred non-AYP students participated in the qualitative portion of the study. During the 12 weeks of the study, these students learned about their learning styles and maintained a portfolio documenting the use of the strategies they learned. Students participated in semi-structured interviews and a focus group.

The data collected from the LSCY for Research Question One were analyzed using a Chi-square Two Variable Crosstabulation examining each of the 22 learning-style variables for each of the two groups, AYP students and non-AYP students. These data were analyzed to determine the similarities and differences in learning-style preferences of both AYP and non-AYP groups. Research Question One and Research Question Two were analyzed using the Statistical Package for the Social Sciences 18.0 (SPSS).

The data for Research Question Two were analyzed using a Chi-square Goodness of Fit test to examine the differences in the categorical data (learning-style preferences) for non-AYP students. The analyses of the learning-style preferences of the non-AYP students were used to determine the significant learning style-preferences of the underperforming students.

Research Question Three and Research Question Four were designed to explain and elaborate upon the qualitative data collected from the interviews and the focus group. The qualitative data were analyzed to understand in what ways tactually-preferenced, non-AYP fifth grade students use their learning-style profiles to design instructional strategies that facilitate

learning and what are their perceptions of using tactual learning-style strategies. Six students meeting the criteria for this aspect of the study were selected from the non-AYP group.

The study used several instruments to gather both quantitative and qualitative data. Students' learning styles were assessed using the LSCY (Burke & Dunn, 1998). The instrument is a valid and reliable instrument designed to measure the construct of learning style. The data from the LSCY were used for the Chi-square analyses answering Research Question One and Research Questions Two.

Using the results of the assessment, six students with a preference to learn with tactual materials were taught about learning styles and their particular preference for learning. They maintained a portfolio that contained their learning style assessment information, learning logs, and self-reflection checklists. Students participated in individual interviews and a focus group. Data collected from these sessions was transcribed and member checked by the participants. The data were coded using HyperRESEARCH 3.7.1 (Researchware, Inc., 1999-2014) for patterns and themes that would explain the research questions.

Summary

The focus of this study was an investigation of the similarities and differences in the learning-style preferences of fifth grade students who are AYP and those that are non-AYP. The learning-style preferences of non-AYP students were analyzed. Students' perceptions and the use of tactual materials for learning were explored qualitatively. The data revealed in this study may provide the needed information to design appropriate learning environments for similar underachievers. Chapter Two will provide a thorough review of the related literature by providing a foundation in learning theory, research studies on learning styles and underachievers, and the use of tactual/kinesthetic strategies.

CHAPTER TWO: REVIEW OF RELATED LITERATURE

Researchers in the field of education have conducted extensive research to create a better understanding of the role that learning styles plays in the learning process. Although the literature covers a wide variety of theories and studies, this literature review will summarize the theoretical foundation of learning styles by reviewing the work of John Dewey. Research on learning styles is presented based on primary researchers in the field including Anthony Gregorc, David Kolb, and Rita and Kenneth Dunn. The Dunn and Dunn Model is explained along with the learning styles of underachievers. Research studies using the Dunn and Dunn model are reviewed with a focus on underachievers and students who are tactual and kinesthetic learners. The role of perception, self-efficacy, and cognitive development with students is included in the chapter.

Theoretical Foundation

Dewey believed that education was built upon unique experiences and that educators must be knowledgeable of these experiences to design future instruction in ways that facilitate individual learning. Dewey called this the theory of experience. His theory was built upon the belief that effective instruction should be driven by experiences of the learner and not on the desire of the teacher or student alone (Dewey, 1910).

Dewey's philosophy evolved after observing schools with traditional learning experiences and those using a more progressive model. In his 1938 book, *Education and Experience*, Dewey wrote his philosophy of education after the founding of his laboratory school where students were active participants in their learning through experiential programming. Dewey (1938) observed that traditional programs were authoritarian in their approach to education and ignored the interests of the learners. Teachers controlled the subject matter,

generally driven by textbooks, and the code of conduct of the students who required conformity. In contrast, he observed progressive programs focused on the learner's interests and impulse, but were so unrestricted by traditional principles that they totally rejected organized learning. These oppositional approaches led to what Dewey called "Either-Or" philosophies (p. 20). He claimed that both approaches were unsatisfactory because they lacked meaningful student experiences, which he espoused as the fundamental element of effective education (Dewey, 1938).

Dewey (1938) viewed traditional and progressive education as conflicting extremes and therefore proposed a new philosophy of education. He recommended that learning become experiential based with experiences that would generate growth and creativity as students participated in future experiences. Dewey defined this as the continuity of experience principle. He explained that this principle is integral to the role the teacher plays in evaluating previous experiences and then deciding on the methods and approaches needed to introduce new learning. Dewey further explained that the individual student's perception of the experience is critical because it is the internal processing of the experience that determines the value of that experience. This identified his second principle of interaction. The student's learning is affected by their individual "needs, desires, purposes, and capacities" (p. 44), in relation to what is happening in the environment.

Dewey (1938) related his principles of continuity and experience to the role that social control plays in the educational process. He believed the educational experience provided students the opportunity of social development by participating in group play, working individually, and with cooperative groupings. Dewey saw the role of the teacher changing from authoritarian to a facilitator of social interaction.

Freedom was an important aspect of Dewey's (1938) philosophy. He observed that traditional methods, rows of desks and moving only on the teacher's direction, hindered the student's engagement in their own learning. Dewey also viewed freedom, not only as a physical movement, but also as a condition of internal processing where students evaluated their desire, purpose, and individual thoughts. Dewey valued the hands-on experience followed by reflection, allowing the student to be actively engaged both physically and mentally.

Dewey (1938) described purpose as a complex operation where a student is observing the environment, connecting past situations, and judging the significance of what is being observed and remembered. Dewey noted in traditional learning experiences, the activity is generally separate from the process of observing and remembering, but teachers have the ability to guide the learner's experiences, making them purposeful. He contended that this would invite the learner to initiate a higher level of thinking by actively connecting the learning environment with prior knowledge of similar experiences.

Building upon Dewey's (1938) meaning of purpose, he identified the role of the instructor as understanding the student's previous experiences and designing a learning situation where the student is able to identify previous experiences, and then capitalize on that experience by building a more complex understanding. In traditional approaches, Dewey observed that content drove the instruction and was selected based on what was done in the past and was thought to be useful. Progressive educators focused on more experiential learning and neglected to organize the learning in a sequential and meaningful way. Dewey wrote that experience itself was not meaningful unless the experience expanded the student's knowledge of factual information and ideas. He identified the teacher as fundamental in the process because they are

continually evaluating the learning by building upon previous experiences and then providing the conditions and experiences necessary to facilitate continual growth.

In his last chapter, Dewey (1938) reiterated the principle that experience is the foundation of learning. He restated that the true meaning of experience is necessary and must include the actual life experiences of the individuals involved. Dewey viewed the process of change in education as difficult, and challenged the educational system to move forward by embedding meaningful opportunities for learning through the experiential education approach.

Dewey's (1938) philosophy of education and the principles of continuity and interaction provided a foundation for the theory of learning styles. Dewey recognized that individual students have "needs, desires, capacities, and purposes" (p. 44) within the learning environment. Dewey wrote, "there is the idea that there is an intimate and necessary relation between the process of actual experience and education" (p. 20). He acknowledged the role of educators to facilitate learning based on the knowledge they have of the individuals they are teaching. His philosophy identified how social development is facilitated through learning individually, with peers, in groups, or with the teacher. Dewey's philosophy provided the context for understanding that learning takes place within an individual and is based on how the elements of learning are accommodated in the educational setting.

Research on Learning Styles

Dewey's theory of experience explained that learning is based on student's experiences, in conjunction with their individual perceptions, needs, desires, and purposes (Dewey, 1938). Providing a foundation to begin his work, Anthony Gregorc identified basic learning styles by studying the observable behavior of good students. His phenomenological research identified individual characteristics of learners that were in-born predispositions (Kozhevnikov, 2007). He

proposed two dimensions for learning – perception and ordering. Perception was either abstract or concrete. The abstract learner was able to visualize and conceptualize, and the concrete learner worked with what was obvious. Ordering was either sequential or random. A sequential learner follows a step-by-step pattern, while the random learner has the preference for skipping steps or starting in a different point (Kozhevnikov, 2007).

The Mind Styles Model is Gregorc's (1979) formalized findings of four learning patterns – Concrete Sequential (CS), Concrete Random (CR), Abstract Sequential (AS), and Abstract Random (AR). Specific preferences for learning emerged through the identification of these patterns that explained a student's appropriate learning environment and the method of instruction best suited for learning. Gregorc proposed that an understanding of how a student learned should be paired with appropriate instruction. His work noted that an on-going mismatch between style and instruction would create frustration and stress for the learner, leading to eventual burnout (Gregorc, 1979). He did, however, believe that individuals should be able to learn outside of their natural style by raising their consciousness, and after being trained, could use the ideas and activities at appropriate times (Cassidy, 2004).

Gregorc developed an assessment instrument for adults, the Gregorc Style Delineator. The instrument is a 40-item inventory that is self-administered. By rank ordering a set of words, the instrument identified the specific mind qualities and the characteristics of Mind Styles learning patterns (CS, CR, AS, AR; Cassidy, 2004). In recent years, Gregorc intentionally focused on adult learning styles and decided not to extend his work to developing a student learning style assessment (Gregorc, 2014).

Dewey's theory of experience also provided groundwork for Kolb's Experiential Learning Theory. David Kolb developed a four-stage theory of learning. Kolb further expounded upon

the work of Dewey by theorizing that: “learning is the process whereby knowledge is created through the transformation of experience” (Kolb, 1984, p. 38). His model consisted of four stages: concrete experience, reflective observation, abstract conceptualization, and active experimentation (Kolb, Boyatzis, & Mainemelis, 2001).

Kolb et al. (2001) identified corresponding characteristics or conditions under which learners are able to learn best, and in specific learning situations, choosing which learning abilities were the best fit. Kolb’s four styles are: assimilators who learn through sound logical theories, convergers who learn through application of theories and concepts, accommodators who learn through hands-on experiences, and divergers who learn best by observing and collecting information. Kolb explained that within this model of learning style, learners develop a preferred way of choosing how to work in a learning situation based on heredity, experience, and the environment (Kolb et al., 2001).

Dewey believed that experience and perceptions of learning shaped future learning experiences. Kolb studied learning experiences and what effect it had on learning styles. He found that “early educational experiences shape people’s individual learning styles by instilling positive attitudes toward specific sets of learning skills and by teaching students how we learn” (Kolb et al., 2001, p. 8). Kolb’s work helped to further explain the role of learning styles at a deeper and more complex level (Kolb et al., 2001).

Kolb’s Learning Style Inventory was a self-assessment tool developed in 1971 and first revised in 1985. It was used to identify a preferred learning style based on Experiential Learning Theory (ELT) and identified the four learning styles of Diverging, Assimilating Converging, and Accommodating. Kolb’s inventory had been used with multiple groups including education. The majority of the education studies focused on higher education (Cassidy, 2004). The K-12

studies primarily focused on the use of ELT as a framework for curriculum design (Kolb et al., 2001). In 2012, David Kolb published a new version of his Learning Style Inventory. The new version expanded from four to nine ways that people learn (initiating, experiencing, imagining, reflecting, analyzing, thinking, deciding, acting, and balancing), and explored how to expand learning outside your preferred style along by measuring learning flexibility (Experience Based Learning Systems, Inc., 2014).

Both Gregorc's work, focused on cognitive processing, and Kolb's work, focused on the approach that a learner uses to process information (Cassidy, 2004), added to the literature on understanding how people learn. Learning style had become a construct that many researchers were investigating to understand the complex interpretation of learning. Dr. Rita Dunn and Dr. Kenneth Dunn began their work in 1967 when they were asked to "design and direct a program that would help 'educationally disadvantaged' children to increase their achievement" by the New York State Department of Education (Dunn & Dunn, 1992, p. 3). Their work involved a rigorous evaluation of the available literature and the significant finding was that students do have "individual differences among students in a way each begins to concentrate on, process, absorb, and retain new and difficult information" (p. 3).

By 1990, the Dunn and Dunn Learning Style Model identified 21 elements in five strands that affect learning: environmental (sound, light, temperature, seating), emotional (motivation, conformity, task persistence, structure), sociological (alone/peer, authority, variety), physiological (perceptual preferences, time of day, intake, mobility), and psychological (global/analytic, hemisphericity, impulsive/reflective; Dunn & Dunn, 1992, p. 3). The model illustrated that "students can master grade-level curriculum when they are taught with strategies or resources that complement how they learn" (Dunn, 2001, p. 68-69). The learning-style

construct has been tested and researched thoroughly with consistent results demonstrating the strength of matching learning-style preference with instruction (Lovelace, 1005).

The Dunn and Dunn Learning-Style Model is based on the following theoretical assumptions:

1. Most individuals can learn.
2. Instructional environments, resources, and approaches respond to diversified learning style strengths.
3. Everyone has strengths, but different people have very different strengths.
4. Individual instructional preferences exist and can be measured reliably.
5. Given responsive environments, resources, and approaches, students attain statistically higher achievement and attitude test scores in matched, rather than mismatched treatments. (Dunn & Dunn, 1992, p. 6)

Based on the research that Rita and Kenneth Dunn analyzed, they determined that learning style is a combination of both biological and developmental characteristics individual to the learner (Lovelace, 2005). In numerous studies, they found evidence that use of identified learning-style preferences facilitated student academic achievement, improved students' attitudes toward learning, and students had better discipline (Dunn & Dunn, 1992, pp. 2-3). Dunn and Dunn reported that these preferences "make the identical instructional environments, methods, and resources effective for some learners and ineffective for others" (Lovelace, 2005, p. 177). Lovelace explained that the combination of preferences that affect an individual's learning style can vary, making students learning in identical environments, with the same methods, and resources, ineffective (2005, p.177).

Researchers, like Gregorc, Kolb, and Dunn and Dunn, were developing instruments to accurately identify learning style since preferences could not be identified accurately through observation alone. Based on the Dunn and Dunn Model, several instruments were developed to identify student learning-style preferences at different ages (Lovelace, 2005). The current instruments available include the Elementary Learning Style Assessment (ELSA) for ages 7-9 (Dunn, Rundle, & Burke, 2007), Learning Style: Clue to You! (LSCY) for ages 10-13 (Burke & Dunn, 1998), Learning in Vogue: Elements of Style (LIVES) for ages 14-18 (Missere & Dunn, 2007), and the Building Excellence Survey (BE) for ages 17 and up (Rundle & Dunn, 1998-2007). Reliability and validity studies have been conducted on each of the assessments. Content validation was conducted following the procedures in the *Standards for Educational and Psychological Tests*, and reliability was established through the test-retest internal consistency process. Specific reliability and validity information is available in the research and implementation manuals on the Learning Styles site (*Learning Styles*, 2014).

Lovelace (2005) clarified, in the Meta-Analysis of Experimental Research Based on the Dunn and Dunn Model, that this model has been developed and studied for over four decades. The revision of the model over the years has led to greater comprehensiveness. It has been more extensively researched, and has consistently demonstrated effective results when a student's individual diagnosed learning style is matched with prescribed instruction. The model was determined to be learning centered, and focused on instructional practice and social interaction (Cassidy, 2004).

The Dunn and Dunn Model is divided into five strands that are used to identify the learning-style preferences of the individual. The first strand is used to examine preferences for the environmental elements of sound, light, temperature, and seating. Dunn and Dunn (1992)

explained that although some students prefer quiet when learning, others will perform better when music is played. Students who are sensitive to bright light may be overstimulated, but work better in soft light. Temperature can be warm or cool. Seating can be formal or informal. Asking students to sit for long periods of time can become uncomfortable leading to fatigue, or the need for a change of position (Dunn & Dunn, 1992). Dunn and Dunn found that 70% of people are affected by the combination of light and seating design. It can become critical for functioning effectively if there is a strong preference for warm or cool, or quiet or sound when concentrating (Mangino, 2008, p. 10).

The emotional elements of motivation, persistence, responsibility, and structure are included in the second stimulus strand. Persistence was found to be biological, and other elements to be developmental (Lovelace, 2005). Students who are persistent require fewer breaks, but some students need the opportunity to work in smaller segments when the need for concentration is high. Motivation, responsibility, and structure are elements that can vary with experiences. Dunn and Dunn found that one difference between students with high IQs and underachievers was motivation. Students with high IQs had higher levels of motivation than the underachievers which suggested underachievers should be taught through their perceptual preferences (Dunn & Dunn, 1992).

Sociological elements are considered developmental. The third stimulus strand is composed of working alone, in a pair, with peers, or with an adult, and the need to work in a variety of ways or in a routine. Studies have shown that students who are permitted to learn through their sociological preferences have had higher achievement scores, better attitudes toward learning, and enjoyed learning more than when traditional methods were used (Lovelace, 2005; Mangino, 2003).

Physiological elements are included in the fourth stimulus strand and examine the perceptual preferences (auditory, visual, tactual, kinesthetic), intake, time of day, and mobility. When the introduction of new learning was through a student's perceptual preference, students were able to remember more, and when a second or third preference was used to reinforce the learning, they were able to achieve significantly more (Dunn & Dunn, 1992, pp. 14-15).

Underachievers have been found to be tactual/kinesthetic learners and can be confused when taught auditorially (1992). According to Dunn and Dunn, "Perceptual preferences may be the most important aspect of learning style" and "either enable or prevent individuals from achieving easily" (Lovelace, 2005, p. 177). Time of day preferences identifies the time a student is likely to learn best. The combination of time of day and perceptual preference affects 70% of all people (Mangino, 2005). "Time is one of the most crucial elements of learning style and demands attention – particularly for potential underachievers" (Dunn & Dunn, 1992, p. 24). Intake is the preference to snack while learning, and the need for mobility while learning includes opportunities to move frequently or another outlet to accommodate this need.

The fifth stimulus strand is composed of the global versus analytic processing-style. Analytic learners prefer to learn in ways that are sequential and build toward conceptualization, and global learners prefer understanding the concept being taught and then processing the details (Dunn & Dunn, 1992, p. 6). From information obtained from this strand, teachers can design instruction based on student preference using different methods or resources that match their style (Dunn & Dunn, 1992). The Dunn and Dunn Learning Style Model is presented in Figure 1.

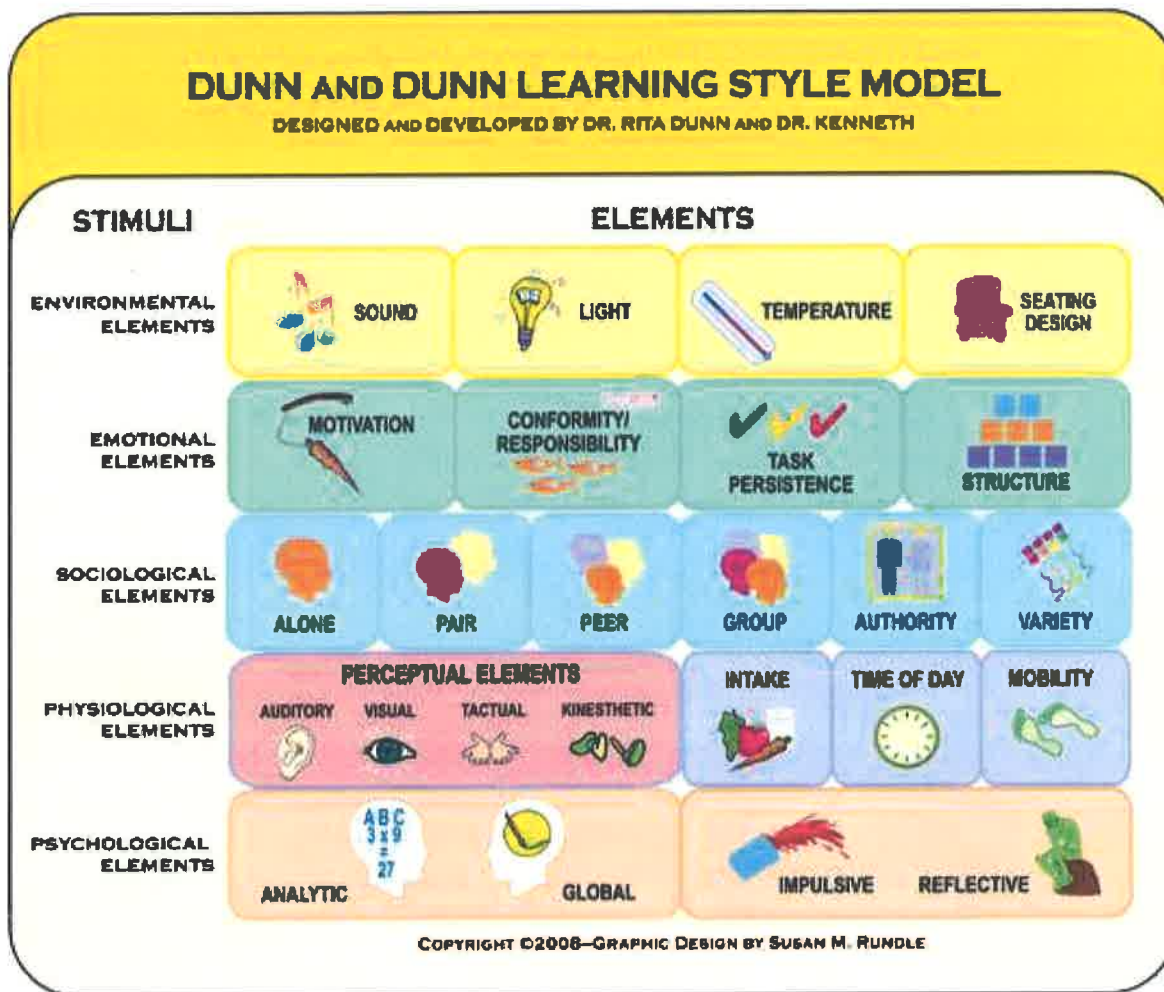


Figure 1. Dunn and Dunn Learning Style Model. Copyright 2008 by Susan M. Rundle. Adapted from “LSCY: Research and Implementation Manual,” by R. Dunn, and K. Burke, 2005-2008, p. 1. Copyright 2005-2008 by Dunn & Burke.

Theory, research, and instruments have provided educators with essential insight into how students think and learn, and how individual preferences affect learning. Based on the Dunn and Dunn Learning Style Model, valid and reliable instruments are available to identify individual student learning style preferences. This information can be used to implement and accommodate students’ preferences through the appropriate methods and resources needed for success.

Learning Styles of Underachievers

In the 1960s, Rita and Kenneth Dunn began theorizing that alternative approaches to instruction could improve the academic achievement of underachievers (Dunn & Dunn, 1979). Their insight into this phenomenon led to numerous studies to identify students who were able to achieve using different strategies. Their theory, supported by extensive research, concluded that when students were taught with complementary methods that matched their individual characteristics, they became more motivated and were able to demonstrate improved academic achievement (Lovelace, 2005).

The learning styles of at-risk students differ from the learning styles of students who perform well at school. Rita Dunn stated that a majority of these at-risk students have seven learning-style traits that establish a similar learning style unlike their peers (Shaughnessy, 1998). Dunn found that at-risk students needed (a) mobility, (b) choice of how, with what, and with whom to learn, (c) a variety of resources, environments, and groupings, (d) to learn during late morning, afternoon, or evening, (e) informal seating, (f) soft lighting, (g) introductory tactual or kinesthetic resources that can be reinforced with visual resources. She also concluded that underachievers have poor auditory memory skills and had difficulty with memorization through traditional instruction contributing to poor academic achievement (Shaughnessy, 1998). Dunn and Dunn (2001) found that “between five and 14 of the 21 elements affect most students” (p. 69).

Friedlander (2010) conducted an investigation of the learning styles of students with autism compared to typical elementary students. There were 52 participants in the study with a medical or educational diagnosis of autism spectrum disorder that attended a school for children

who have developmental disabilities, and 60 elementary school students who did not have a known diagnosis of autism.

To assess students' learning styles, Friedlander (2010) used the Elementary Learning Style Assessment (ELSA; Dunn, Rundle, & Burke, 2007). The 60 elementary school students were chosen randomly from a population of 8,687 students who closely matched the age, academic performance, socioeconomic status, and cultural composition of the group of students with autism. The learning-style preferences of the students with autism were analyzed and reported for the group, and the learning-style preferences of both groups were compared and analyzed.

The data collected by Friedlander (2010) indicated that students with autism have common learning-style preferences. The Chi-Square Goodness of Fit Test revealed that there was a significant difference ($p < .025$) in 24 of the 25 preferences tested. Environmentally, students with autism preferred to learn with background noise, bright light, and warm temperature. In social settings, these students reported that peer collaboration and interaction were important. They preferred to learn best with authoritative adults. Friedlander (2010) found that students with autism preferred learning through a variety of social settings including peer collaboration, working in one-to-one and small groups, and working with authoritative adults in a variety of ways. The physiological elements that were preferred were not snacking while learning, and that they learn through a variety of perceptual modalities. The emotional preferences of the students with autism included a need for structure and authority, and were motivated by others. They preferred to multi-task and have frequent breaks while working. Students reported that they were more global than analytic learners.

The analyses were conducted using a Chi-square Crosstabulation and results showed that there were four learning-style preference differences ($p < .025$) between elementary school students with autism and their typical peers (Friedlander, 2010). The significant differences were in the elements of light, authority, auditory, and reflective/impulsive. The students with autism had a preference for bright light and their peers had no preference. The students with autism had more of a preference for learning with authority than their typical peers. Friedlander's (2010) analyses revealed that students with autism had a preference for learning by listening and fewer typical students preferred learning by listening. Students with autism saw themselves as less reflective and typical students saw themselves as more reflective.

Dunn and Dunn (1992) maintained that motivation “develops as a reaction to each learner’s experiences, interest in the content that is being learned, and the ease with which it can be mastered” (p.144). Numerous studies concerning accommodating students’ learning-style preferences supported that student achievement was higher than students whose styles were not accommodated (Lovelace, 2005). Dunn and Dunn (2005) reported that a multi-sensory approach (auditory, visual, tactual and/or kinesthetic) did not benefit all students. Their research found that students should initially be exposed to new and difficult academic material through their primary perceptual strength, and higher achievement test scores could be attained when the appropriate resources were implemented. Evidence to support these findings can be found from primary school through adult, in various academic subjects, and across a spectrum of student classifications (Braio, Beasley, Buchanan, Dunn, & Quinn, 2001; Brand, Dunn, & Greb, 2002; Farkas, 2003; Fine, 2003; Friedlander, 2010; Geiser et al., 2000; Lister, 2005; Nunn, 1995; Rayneri, Gerber, & Wiley, 2003). Researchers have continued to study the effects of tactually

preferenced students from kindergarten through high school (Farkas, 2003; Fine, 2003; Lister, 2005; Schiering & Dunn, 2001).

Through testing and data collection over two decades, Dunn and Dunn (2005) analyzed the learning styles of students who were struggling to learn with traditional instructional methods that focused on auditory and visual presentation. These students were identified as tactual learners; those who need to manipulate their learning materials using their hands. Dunn and Dunn (2005) found this group of students was able to learn significantly better, retain more, and in less time when they were instructed using hands-on resources.

The Dunns' (2005) research concluded that tactual materials were better for average students, students with disabilities, and underachievers, than with lectures and readings. The research of O'Connell, Dunn, and Denig (2001) supported these findings. They found that average and highly-achieving science students scored statistically better than those in a control group using teacher-made tactual resources, and scored the highest when students created their own tactual resources. Student attitudes toward learning increased significantly (O'Connell et al., 2001).

Based on the research presented, we can conclude that individuals have unique learning styles and the sub-groups often identified as underachievers, also have unique learning styles that often do not match the instructional methods of a typical traditional classroom. Addressing the learning preferences of students with appropriate strategies and methods that are complementary to their learning style will improve attitudes toward learning and school, and improve academic achievement. The research showed that students who do not learn using conventional methods are able to be successful when their learning styles are identified (Brand et al., 2002; Lovelace, 2005).

Research Using the Dunn and Dunn Learning Style Model

Lovelace (2005) conducted a meta-analysis of experimental research based on the Dunn and Dunn Learning Style Model. This quantitative synthesis was performed on 78 original research investigations that were conducted between 1980 and 2000. The participants totaled 7,196 and produced 168 effect sizes. The inclusion criteria were met by every study that was included. The study had to be experimental or quasi-experimental; used one of the Dunn and Dunn Learning Style instruments; addressed one or more of the learning-style elements in the environmental, emotional, sociological, and physiological strands; and have enough statistical information to calculate effect sizes.

The meta-analysis revealed no effect sizes that were negative. Based on the final calculations of effect sizes for achievement and attitude, Lovelace (2005) determined that “traditional education never produced higher achievement or attitudes than did learning-style instruction in any of the studies investigated” (p. 179). The findings provided evidence that when students’ learning styles were assessed, and complementary instruction was used for learning, students showed increased achievement scores and increased attitudes toward learning. The findings were consistent with the previous meta-analysis conducted by Sullivan (1993). The approximate mean effect-size value (r) was .40. The meta-analysis of experimental research based on the Dunn and Dunn Learning Style Model confirmed the positive effects of combining learning-style preferences with complementary instruction (Lovelace, 2005).

Rayneri et al. (2003) conducted a study on the learning styles of gifted achievers and gifted underachievers in sixth, seventh, and eighth grades. The purpose of the study was to compare the learning style needs of low-achieving gifted students and high-achieving gifted

students. Additionally, the researchers examined ways that gifted students' learning styles are related to the grades they earn.

The study considered students to be low-achieving gifted students if their grade-point averages (GPA) were below 85 on a 100-point scale (Rayneri et al., 2003). In this study of 80 gifted students, 16 were identified as low-achieving. An additional 18 students had GPAs between 85 and 89 and were not included in the comparison of learning styles. The total number of students included in this study was 62. Rayneri et al. (2003) noted that other researchers have found the highest percentage of gifted underachievers in seventh grade. This study's subjects were in line with this finding with two in sixth grade, nine in seventh grade, and five in eighth grade.

The Learning Style Inventory (LSI; Price & Dunn, 1997) was administered to all 80 students and the results of the 52 identified students were used to determine the similarities and differences between the high-achieving gifted students (46) and the low-achieving gifted students (16; Rayneri et al., 2003). These data were converted into T-scores to report student preferences. The researchers found that the students were similar in learning-style preference for warm temperature, informal seating design, responsibility (nonconformity), parent motivation, and teacher motivation. Both groups indicated that they did not need authority figures to be present and preferred to learn in a variety of ways. Eating and drinking while studying, learning in the afternoon or evening, and using tactual and kinesthetic modalities were similar for both groups. Low-achieving gifted students however, showed a much stronger need for tactual and kinesthetic modalities (Rayneri et al., 2003).

The LSI elements that revealed the greatest difference in mean preference scores were in the categories of noise, structure in assignments, visual learning modalities, and mobility in the

study (Rayneri et al., 2003). More low-achievers preferred to have sound while learning or studying and high-achievers preferred quiet. High-achievers preferred little structure while low-achievers showed a need for more structure. Low-achievers preferred visual learning, but this style was not a preference for the high achievers. Half of the low-achievers felt mobility was helpful, while 70% of the high-achievers felt they needed movement for learning (Rayneri et al., 2003).

Specifically concerning the low-achieving gifted students, Rayneri et al. (2003) found the frequencies revealed that 69% of this group had a strong preference for learning with tactual resources, and 50% had a strong preference for kinesthetic learning. The frequencies also showed that only 12% of this group had a preference for auditory learning. The researchers concluded that low-achieving gifted students had a need to be engaged in learning that accommodated for their needs through more visual, tactual, and kinesthetic modalities. The lack of a preference for auditory learning indicated that this group would not learn best through lecture or other listening activities.

Rayneri et al. (2003) found both groups were identified as global learners. The low-achievers showed a stronger preference for global learning with LSI scores that indicated a greater preference for sound, dim lighting, tactual, and kinesthetic activities, and a low preference in persistence. Based on the results of the study, it was suggested that accommodations should be considered for students who concentrate for short periods of time, need frequent breaks, and prefer to work on several tasks at the same time.

The effects of using learning styles as an intervention with at-risk middle school students was researched by Nunn (1995). The study focused on systematic implementation of learning styles and strategies instruction and the effect on academic achievement and locus of control.

There were 103 student participants in grades seven and eight. These students were representative of the at-risk and non-at-risk population. There were 59 males and 44 females. This group was 93% White, 6% African American, and 1% Hispanic (Nunn, 1995).

At-risk and non-at-risk students were assigned to comparison groups (Nunn, 1995). The groups were: At-Risk Intervention, At-Risk Nonintervention, and the General Education. The At-Risk Intervention group was composed of students who had problems with school performance and would receive the intervention. The At-Risk Nonintervention group was composed of students who had problems with school performance but would not receive the intervention. The General Education control group consisted of students with average academic performance. The students' locus of control was measured with the Nowicki-Strickland Locus of Control Scale (1973) and measures of academic achievement were taken from student records (Nunn, 1995).

The learning-style strategy and intervention course was designed to help students use learning styles and apply strategies to their learning (Nunn, 1995). This class met for one class period every other day for the school year. The goal was to facilitate positive adjustment to school with the implementation of learning styles. All intervention students had their learning styles assessed. Profiles were created and the information was explained to the students. The course provided the students with strategies that would complement their learning styles. Students were encouraged to set goals, problem-solve ways to improve their school performance, and use their learning styles and strategies by meeting with their teachers throughout the year (Nunn, 1995).

Students in the at-risk intervention group significantly improved their grade point averages as reported by Nunn (1995). A significant treatment effect was obtained with Grade

Point Average (GPA) $F(2,88) = 43.14, p < .0001$). There was a significant interaction effect $F(2,88) = 4.79, p < .01$. Students in the At-Risk Intervention group significantly increased their GPA, At-Risk Nonintervention group students significantly decreased their GPA, and the General Education group showed no change in their GPA. Significant main effects $F(2,80) = 3.12, p < .05$ were revealed for the intervention group. These students increased their GPA scores and decreased their external locus of control. Nunn's (1995) analyses provided a tentative support for learning-style intervention and its effect on student performance in school.

An exploratory study on fifth grade students' science achievement using learning-style instructional materials was conducted by Schiering and Dunn (2001). The study also explored the use of complementary instructional materials matched to a student's individual strengths and the effects on metacognition and the students' ability to teach themselves. The students were in either the control group and received traditional instruction, or the experimental group using learning-style accommodations and self-teaching based on the Dunn and Dunn Learning Style Model.

Students in the experimental group were administered a pretest on learning style, and then took the Learning Style Inventory (LSI; Dunn, Dunn, & Price, 1996). Students received instruction concerning metacognition and were introduced to the Dunn and Dunn Learning-Style Model. Schiering and Dunn (2001) provided students with the results of their LSI and they became familiar with learning-style instructional materials by using a Multisensory Instructional Packet (MIP). The MIP used an approach to learning through different modalities and it provided a self-correcting resource that focused on a single concept. The package was used to allow students to select the resources that were complementary to their individual learning style.

Students were directed to create materials that would be beneficial for self-instruction of the science unit.

Schiering and Dunn (2001) reported that students in the control group were administered a pre-test on Living Communities from their science textbook. These students received traditional instruction daily during a 50-minute class period for two weeks. The traditional instruction included lecture, transparencies, note taking, and class discussion. Students were not assigned homework. The students were administered the posttest which was identical to the pretest.

Following the learning style assessment, students completed a learning-style multisensory instructional packet on the science unit (Schiering & Dunn, 2001). Students in the experimental group were able to create learning resources (tactual and kinesthetic) that matched their primary perceptual strength. The experimental group scored significantly higher in all sub-categories and overall science knowledge. Schiering and Dunn (2001) reported the results revealed a strong correlation ($p < .01$) pertaining to students being able to learn in several different ways as opposed to traditional methods. The experimental group improved their attitudes toward learning, and chose to share their learning resources with other classmates.

In 2003, Fine reported the results of a study that was conducted at his New York State high school where he determined the learning-style preferences of the special education population and of the regular education students. He further analyzed the differences between the two groups to find patterns in the data that would be beneficial for teachers when designing instruction. After administering and analyzing the data from the Learning Style Inventory (LSI; Dunn, Dunn & Price, 2000) revealed that the special education students did indeed have learning-style preferences that differed from that of the regular education students in nine of the

21 elements of the Dunn and Dunn Learning Style Model. Fine (2003) used these differences to accommodate student learning-style preferences in the self-contained science classroom. The learning environment was changed to informal seating, adapted for student preference for sound, and provided a choice of lighting. Incrementally, learning-style resources were added for self-instruction along with tactual and kinesthetic materials. Students were tested with pretests and posttests on units in modern biology and human systems.

The study included 214 students in regular education and 208 students identified as special education (Fine, 2003). The 208 special education students were in grades nine through 11 and were classified as emotionally disturbed or learning disabled according to their Individualized Education Plan (IEP). All of the special education students and a random sample of regular education students (grades 9 through 12) were administered the LSI. Fine (2003) determined through statistical analyses, that there were significant differences between the two groups in nine of the 21 elements. The elements with significance included light, temperature, motivation, persistence, responsibility, authority, mobility, parent motivation, and teacher motivation. This study confirmed that there are significant differences in learning style between regular education and special education students.

The researcher went on to analyze the effects of learning-style matched to specific instructional approaches on achievement, attitudes, and the behavior of the special education students (Fine, 2003). This part of the study included 14 special education students in grades 9 through 11 in a self-contained science class. Seven science units were taught with each unit lasting eight days. Units one and two were taught with traditional methods of instruction. Units two, three, and four had changes to the instructional environment to accommodate for student preferences for design, light, and sound. During units five and six, students used materials that

were teacher created or created by themselves to match the unit's content. Some of the materials used included Electroboards, Vocabulary Wheels, Flip-Chutes, and floor and wall games to accommodate for students' tactual and kinesthetic preferences. All students were given a pretest and posttest on science content for each unit (Fine, 2003).

The analyses of the data showed that student achievement improved significantly with the incremental implementation of learning-style strategies (Fine, 2003). The most significant increase in student achievement was during the implementation of sound in the instructional environment. The pre-test to post-test gain was 24.86 points. The results showed that students' achievement scores increased significantly with the use of tactual and kinesthetic materials during instruction. The pre-test to post-test gain was 24.29 points. Fine's (2003) analyses confirmed that special education students taught through learning-style approaches demonstrated significantly better achievement scores than when they were taught with traditional methods of instruction.

Two long-term assessments were administered to measure retention of science content. The first assessment covering units one through four, was given immediately following unit four (changes to instructional environment), and the second assessment was administered 30 days after the completion of unit seven (teacher-created and student-created tactual and kinesthetic materials). Fine (2003) reported the results of these assessments indicated that students' achievement increased with the changes to the instructional environment (design, sound, and light) but tactual and kinesthetic instructional materials produced a higher gain in the mean score. The mean gain between the first assessment (79.14) and the second assessment (85.71) was 6.57. Additionally, traditional instruction for students with disabilities was the least effective.

The Comparative Value Scale (CVS; O'Connell, 1999) was used to assess students' attitudes using with a pretest and posttest. The change in the attitudes of the special education students was significant ($p < .05$) when instruction was matched with students' preferences for learning (Fine, 2003). The students compared the traditional instruction to learning style approaches. The study revealed the most favorable learning style condition was when students were able to create and use their own learning materials. Students rated this condition at 92.9% or Very Helpful.

Fine (2003) reported the behavior of the students improved over the course of the study as learning style approaches were introduced. A behavior point system was used and students could earn up to three points a lesson for being on time, on task during the first half of class, and on task during the last half of class. Students earned the most behavior points during unit six when they were actively engaged in their learning using the student-created materials receiving a perfect score for all eight days of the unit.

The study confirmed that special education students and regular education students have different learning styles. Over the seven weeks, Fine's (2003) data revealed that the special education students significantly increased their academic achievement as learning-style strategies were introduced. Students' attitude scores were high in the favorable range when learning-style accommodations were implemented. Students specifically identified the use of student-created materials as being very helpful when learning, retaining, and enjoying instruction. Appropriate student behavior during instruction increased and lateness was eliminated.

An experimental research study on the effects of using tactual and kinesthetic learning-style instructional strategies with sixth grade students classified as Learning Support Students (LSS) and Regular Education Students (RED) was conducted by Lister (2003). The study

investigated the learning-style characteristics of both groups and the effects of traditional instruction versus learning-style responsive instruction on achievement. Attitude toward the learning style instructional treatment was assessed.

The participants in the study were 93 sixth grade students, and 32 were identified as LSS based on the achievement scores on the TerraNova Standardized Test (Lister, 2003). The remaining students were identified as average (RED) or above average (HA). Students were randomly assigned to four homeroom classes. All classes received both traditional and learning-style responsive instruction during the investigation. The students had their learning-style preferences assessed using the Learning Style Inventory (LSI; Dunn, Dunn & Price, 2000) prior to the study. Lister (2005) used the Semantic Differential Scale (Pizzo, Dunn, & Dunn, 1990) to compare the attitudes of the LSS group toward learning using a traditional to learning using a learning style teaching method that included tactual and kinesthetic materials. Both groups were administered a pretest and a posttest for each of the four parts of the social studies unit to assess students' knowledge of content. The traditional materials included stories, comprehension sheets, and worksheets. The learning-style responsive materials included Flip-Chutes, Electroboards, Task Cards, Peg Boards, large floor puzzles and floor games. All of the learning-style materials were self-correcting.

Instruction was delivered in four sections. Both Part A and Part C were taught using traditional methods with traditional homework. In Part B and Part D, students were taught using tactual and kinesthetic resources and tactual homework was assigned. All parts had five, 45-minute lessons. Lister (2005) reported, the results of the LSI showed that the LSS were significantly different in five of the learning-style elements. Results revealed that the LSS were less motivated than the HA students; less Persistent than the RED and HA students; less

responsible (conforming) than the RED and HA students; wanted less structure than the HA students; and wanted closer supervision by authority figures than did the RED students.

Significant main effect interactions for instructional methods were revealed (Lister, 2003). The analyses showed mean-gain scores in all four treatments. LSS mean gain scores by part were: 32.5 for Part A (traditional), 55.03 for Part B (learning style), 20.16 for Part C (traditional), and 64.91 for Part D (learning style). The results for each part were significantly different from each other as indicated by the within-subject effects ($F = 67.007, p < .05$). The pairwise comparisons for instructional treatments showed that the LSS group performed significantly better with both learning-style instructional treatments than they did with traditional treatments. The LSS attitudes were assessed with the Semantic Differential Scale. The analysis indicated that there was a significant difference of positive attitudes toward the learning-style instructional treatments, $p < .05$ (Lister, 2005).

The results of Lister's (2005) experimental study on the use of learning-style instructional strategies produced significant results. The study confirmed that there are specific learning-style characteristics among LSS, RED, and HA students, specifically, low-achievers being less persistent, less motivated, and less responsible. The results of the study evidenced higher achievement and attitude scores for LSS when taught with responsive learning-style instructional methods as opposed to traditional teaching methods. The study supports the essential need to identify students' learning-style characteristics and implement appropriate learning-style instruction that complements the needs of underachieving students.

In 2003, Farkas conducted an experimental study on the effects of traditional instruction versus the use of learning-styles instructional methods on middle school students' achievement, attitudes, empathic tendencies, and transfer skills while learning about the Holocaust. Four

classes participated in the four-week study with two classes as experimental and two classes as control with a total of 105 students with average achievement levels. The instrumentation used to identify learning-style preferences was the Learning Style Inventory (LSI; Dunn, Dunn, & Price, 2000), the Semantic Differential Scale (Pizzo, Dunn, & Dunn, 1990) for attitudes toward instructional approach, the Balanced Emotional Empathy Scale (Mehrabian, 2000) to measure degrees of sympathy toward people, the Moral Judgment Inventory (Colby & Kohlberg, 1987) to measure moral development and transfer of knowledge, and pretest and posttest on Holocaust content that measured achievement (Farkas, 2003).

The concept of learning styles was introduced to the participants, and the teacher read aloud two books on learning styles prior to their LSI. The results of the LSI were used to form the experimental group according to learning-style preferences, and the control group that received course content through traditional methods. The experimental group was exposed to instructional strategies that would be used along with becoming familiar with varied materials such as Flip Chutes, Task Cards, Programmed Learning Sequences, and Contract Activity Packets prior to instruction to avoid a novelty effect. The five units of study were taught over 20 consecutive days (Farkas, 2003).

The results of the study showed that the experimental group using multisensory instructional strategies evidenced greater achievement gains ($p < .001$) than the control group that received traditional instruction (Farkas, 2003). Attitude toward instructional approach was also statistically significant. The students in the experimental group had a more positive attitude toward their instructional approach ($p < .001$) than the control group. The mean empathy gain scores showed that the experimental group had significantly higher student empathy-toward-people test scores ($p < .001$) than the control group. The assessment of moral development and

transfer of knowledge showed significantly higher scores for the experimental group ($p < .001$) than the control group. Farkas (2003) reported that the results of the study indicated that when middle school students are instructed with a learning style based approach, there was significantly higher achievement, more positive attitudes toward instructional approach, a higher degree of sympathy toward people, and greater moral development and transfer of knowledge than the students taught with traditional methods.

In 2002, Minotti conducted an experimental study on the use of learning style homework prescriptions with heterogeneously grouped sixth grade students in an urban setting. The group was predominately Hispanic and African American and their academic standing was based on standardized testing, grade point averages, and teacher recommendations that ranged from low-achievers to gifted and talented. The participants were randomly assigned to a Control group and an Experimental group.

The study was conducted using the Learning Style: Clue to You! (LSCY; Burke & Dunn, 1998), the Semantic Differential Scale (SDS; Pizzo, 1981), a Homework Tips booklet, a learning style pretest, classroom achievement tests, and student study logs (Minotti, 2002). The LSCY provided learning-style preferences along with homework prescriptions for each student. A pretest and posttest using the SDS was used to assess attitudes toward learning style, and attitudes toward homework. There was a pretest to assess students' prior knowledge of learning styles. Mean achievement scores in academic subjects was used as a baseline and these scores were compared to unit test scores following the two-week treatment period. Students completed study logs were used to verify compliance and assess whether study skills were used as outlined by the homework prescriptions.

Students were administered the attitude surveys and a pretest on knowledge of learning styles prior to treatment. The experimental group received an introduction to learning styles through an animated slide show with a group discussion, while the control group saw and animated slide show on homework and learning strategies. A copy was given to parents of both groups. The experimental group completed the LSCY to determine students' individual learning-style preferences. The control group received a Homework Tips booklet with a copy for parents. The experimental group received homework prescriptions based on the LSCY. The prescriptions were explained to the students and they were directed to use the suggestions for studying and doing homework for a two-week period. Parents received a copy of the homework prescriptions. All students were to maintain the study logs on what they did differently based on Homework Tips or the learning-style prescriptions (Minotti, 2002).

Following the two-week period, the control group met as a group to discuss how they used the Homework Tips, and the experimental group met to discuss the learning-style prescriptions. Both groups took the posttest SDS as a measure of attitudes toward studying and homework assignments. Posttest measures of academic achievement were based on the classroom assessments for academic subjects during the treatment period. The results of the study revealed the experimental group evidenced a significant increase in knowledge of learning styles from pretest to posttest. Mean scores increased from 1.54 before treatment to 3.78 out of 4 after treatment for students who utilized learning-style based homework prescriptions and implemented those strategies while studying. The control group made marginal gains with mean scores of 1.53 before treatment to 1.94 after treatment (Minotti, 2002).

Students in the experimental group had larger academic gains when using learning-style based homework prescriptions when compared to the control group who used traditional study

methods. The mean achievement scores increased significantly for the experimental group for all areas assessed. Further analyses revealed a significant interaction for both subject and group, $p < .001$ (Minotti, 2002).

Both the experimental group and the control group were determined to have similar mean scores for attitude toward completing homework and studying prior to the treatment (Minotti, 2002). Following treatment, the posttest SDS showed a 10-point difference in attitude toward homework. This was significant at the $p < .05$ for the experimental group. The control group had a marginal increase which was not found to be significant.

The mean attitude scores for the experimental group showed a significant difference from pretest to posttest indicating that the students who utilized homework strategies that matched their learning-style preferences would demonstrate increased attitudes-toward-learning styles. The control group demonstrated a 3- point gain in mean attitude test scores from pretest to posttest. The experimental group demonstrated a 13-point gain in attitudes-toward-learning styles from pretest to posttest indicating a difference at the $p < .001$ level (Minotti, 2002).

A summary of the findings indicated that students who had their learning-style preferences identified through the LSCY, and were provided with individualized homework prescriptions showed significant improvement in knowledge of learning styles, academic achievement, and attitude toward homework and learning styles. All four research hypotheses were supported by the analyses of the data (Minotti, 2002).

In 2001, Braio et al. conducted a study to determine whether achievement scores and attitude toward reading would increase with incremental implementation of learning-style strategies by students with disabilities and low achievers. The study was conducted over a 10-week period with 81 special education students and 35 regular education students from the

fourth, fifth, and sixth grades of a low-socioeconomic, urban elementary school. The students were of mixed ethnicity, 31% African American, 41% Hispanic, and 29% White or other. The Special Education students (SPED) had been classified by the Committee on Special Education using New York State guidelines, and the Regular Education students (RE) were determined to be low-achievers based on standardized testing that placed them two years below grade level.

In the study, eight teachers (7 SPED, 1 RE) participated in a three-day training by the researchers. During the training, the teachers learned how to incorporate elements of sound, light, design, mobility, and perception using auditory, visual, tactual, and kinesthetic resources. They were taught how to explain learning styles to students, and how individual preferences could help students to learn. The teachers learned how to administer and interpret the Learning Style Inventory (LSI; Dunn, Dunn, & Price, 1990) and the Semantic Differential Scale (SDS; Pizzo, 1981; Braio et al., 2001).

The researchers provided instruction on how to redesign classrooms to accommodate for students' environmental preferences. They created auditory, visual, tactual, and kinesthetic instructional resources to accommodate for students' perceptual strengths. Together they planned activities, created pretests and posttests for structural analysis units, and determined how scores would be recorded in a similar manner (Braio et al., 2001).

Prior to the beginning of the study, all participants were read a storybook to introduce learning styles and to enhance the accuracy of the testing. The students were assessed using the LSI and the SDS. The results of the LSI identified three groups, students with environmental preferences (EMP), multiple preferences (MULT), and no preferences. These groups would be used in the statistical analyses to determine significance (Braio et al., 2001).

The 10-week study was implemented in 5 phases, 20 minutes per day while learning structural analysis skills (Braio et al., 2001). The teachers used a researcher prescribed script during the lessons. The students were pretested at the beginning of each phase to establish prior knowledge and took a posttest after two weeks to assess achievement under the condition. Pretest and posttest were the same 20-item exam. The materials and tests for each of the units were validated by the participating teachers, one of the authors, and one teacher external to the study,

Phase one had no learning style accommodations and was taught with traditional methods. It was used as the baseline for the study. The SDS was used to assess their attitudes toward traditional instruction (Braio, et al., 2001).

In phase two, the teacher explained the results of the LSI. The students, along with the teacher, created a chart that identified their learning-style preference for sound, light, design, mobility, and perception (auditory, visual, tactual, kinesthetic) which was displayed. In this phase, 66 SPED and 20 RE students indicated a learning-style preference for environment or mobility. They were able to choose the appropriate accommodation (seating, lighting, sound) and could move when needed with permission. The remaining students did not have learning-style preferences and remained in the traditional setting (Braio et al., 2001).

In phase three, tactual and kinesthetic instructional resources that teachers created were introduced (Flip Chutes, Task Cards, Electroboards, and floor games). Environmental and mobility preferences were kept intact, and tactual and kinesthetic preferences were added. All students used the tactual/kinesthetic resources even if it was not identified as a preference on the LSI. This phase involved 73 SPED and 32 RE students. The remaining students had no accommodations (Braio et al., 2001).

During phase four, the teachers matched all perceptual preferences and continued to accommodate for environment and mobility. Seventy-four SPED and 32 RE students had learning-style preference accommodations. The remaining 10 students had no accommodations. The learning style implementation phase concluded after the posttest. The SDS was administered to assess attitudinal changes resulting from learning-style intervention (Braio et al., 2001).

All learning-style accommodations were eliminated during phase five. Traditional instruction was delivered using lecture, chalkboard work, textbooks, and worksheets. After this two-week instructional period, a posttest and the SDS were administered (Braio et al., 2001).

According to Braio et al. (2001) the purpose of this study was to examine if incremental implementation of learning style strategies would affect the achievement and attitudes of special education and low achieving students. Achievement and attitude scores were reported for special education students and regular education students.

Braio et al. (2001) reported the results for the special education students showed statistically significant changes across phases with both the EMP, $F(4, 90) = 6.41, p < .001$, and MULT, $F(4, 188) = 6.39, p < .001$. Further analyses revealed that SPED students in the EMP group showed significantly higher achievement in phases two, three, and four when learning-style strategies were implemented. Achievement was not significantly different during the phases. The researchers concluded that achievement increased with the learning-style accommodations for students with environmental and mobility preferences, and no detrimental effects were revealed when they were removed from instruction.

Also, results showed that special education students in the MULT group showed higher achievement during the treatment phases. MULT students showed significantly higher gains

during phase 3 (tactual/kinesthetic resources) when compared to the baseline phase. Tukey's HSD was used to construct simultaneous confidence intervals. The results showed a significant difference ($HSD = 12.76, p < .05$) between phase one and phase four. The researchers concluded that being in the MULT group "seemed to have a cumulative, positive effect on achievement" with the SPED students (Braio et al., p. 22). There was a detrimental effect upon removal of the learning-style accommodations.

The SDS scores of SPED students increased throughout the study, and there was a decline in the scores when learning-style accommodations were removed during phase five. The split plot ANOVA showed a statistically significant change in the attitudes of SPED students identified with learning-style preferences across the phases of the study, $F(3, 230) = 13.51, p < .001$. The Tukey post hoc comparisons showed that during phases where learning-style interventions were used, SPED students showed more positive attitudes ($HSD = 3.16, p < .05$) than during phases of traditional instruction (Braio et al., 2001).

According to the reported results, the RE students in the EMP group did not show a significant increase in achievement across the phases, but did show a decline in achievement during the last phase where learning-style accommodations were eliminated. Braio et al. (2001) concluded that incremental implementation of learning-style accommodations did not affect achievement, accommodating a single learning-style preference in a RE setting only had gradual effects, and that achievement increased when additional accommodation for preferences were implemented.

Braio et al. (2001) reported that for RE MULT students, achievement increased with the introduction of learning-style accommodations. They found that during phase four, when all learning-style preferences were complemented, there was a decline in achievement. There was

also a decline in achievement when all learning-style accommodations were removed during phase five.

Similar results for attitude between RE and SPED were revealed. Attitude scores increased with the addition of learning-style accommodations, and there was a decline in scores when they were eliminated. There was a statistically significant change in attitude toward instruction scores across the phases of the experiment, $F(3, 98) = 3.75, p = .0134$. Tukey post hoc comparisons showed that attitudes toward instruction were significantly more positive at the end of the intervention than at the beginning ($HSD = 5.00, p < .05$; Braio et al., 2001).

An investigation on the effects of learning-style awareness and responsive study strategies on achievement, incidence of study, and attitudes of suburban eighth-grade students was conducted by Geiser et al. (2001). Students were assigned to either a traditional study group (average and below average), or a learning-style-responsive group (average and below average). The study was conducted for six weeks, and at the end of each two-week phase students were assessed on knowledge of mathematics and questioned if they had studied for the tests.

During phase one students were administered the Learning Style Inventory (LSI) to diagnose individual learning-style preferences and the Semantic Differential Scale (SDS) to assess attitudes. Two weeks of mathematics instruction occurred without any intervention and two math assessments were administered. Students were questioned if they had studied for the tests (Geiser et al., 2001).

In phase two, students were provided with information on study skills. The traditional group learned studying should take place in bright light, quiet, and at a desk or table. Additional information on note-taking, questioning and reviewing was provided as were other traditional methods of studying. The learning-style-responsive group was provided with copies of their

learning style profiles with prescriptive study skills strategies, but without any direct instruction on studying based on the profile. Again, two weeks of mathematics instruction took place, two assessments were administered as well as a question about studying for the tests (Geiser et al., 2001).

In the final phase, three lessons on study strategies were included. The traditional group received additional information on studying that followed up on the information provided in phase two. The learning-style-responsive group received prescriptive training on their individually diagnosed learning style which included environmental, emotional, sociological, and perceptual preferences. In the final two weeks mathematics, instruction took place with two math assessments. Students were again questioned about studying for the tests (Geiser et al., 2001).

The following results were reported by Geiser et al. (2001). Test one was eliminated from the study due to an unplanned interruption during phase one. Test two showed a significant difference ($p < .01$) in achievement between the two groups (average and below average). Using a series of Analyses of Covariance, the researchers found that there was a significant difference ($p < .001$) between the groups on test three. There was no significant difference found on tests four, five and six. They concluded that there was limited support for learning-style-responsive strategies with the average students. No other results were significant.

The Geiser et al. (2001) study showed support for the benefit of using learning-style-responsive study strategies with below-average students. Tests one and two showed no difference between the groups. When the scores of test one and test two were used as covariates, the analyses revealed that there was a significant difference ($p < .05$) on tests three, four, and six between the groups. Test five revealed no significant difference between the groups. The

below-average students benefitted from learning-style strategy prescriptions over traditional study methods.

The Semantic Differential Scale (SDS) was administered to determine attitude toward mathematics at the beginning and end of the study to all students. At the beginning of the study, students in the traditional group scored significantly higher on the SDS than the learning-style-responsive group. Geiser et al. (2001) reported at the end of the study, the learning-style-responsive group, after learning about their preferences, scored significantly higher ($p < .01$) than the traditional group on attitudes toward mathematics. The data revealed that average students had a significant difference ($p < .01$) between the traditional and learning-style-responsive group.

There was no significant difference between the pretest and posttest for the average group. Geiser et al. (2001) reported that the average students in the learning-style-responsive group showed a significant difference in attitudes toward mathematics scores ($p < .01$) from pretest to posttest after learning about their learning styles and were taught responsive strategies for studying. The results indicated the below average learning-style-responsive group showed significantly higher attitudes toward mathematics scores ($p < .01$) than the traditional group. There was no significant difference between or within the groups when studying and homework were analyzed. The researchers concluded that students did not study longer but having knowledge of their learning style and strategies for studying allowed them to effectively study and complete homework (Geiser et al., 2001).

According to Brand et al. (2002) students with Attention Deficit Hyperactivity Disorder (ADHD) were often provided with learning environments that were mismatched to their individual preferences. Their research found there was conflicting information about the instruction of ADHD students. Advice to teachers was very generic to the disorder and assumed

that all ADHD students learned in the same manner. Based on the lack of research in this area Brand et al. (2002) conducted their own investigation of the learning styles of students classified as ADHD.

Two studies that identified the learning styles of students with ADHD were conducted by Brand et al. (2002). Both studies examined the learning styles of students who were medically diagnosed with ADHD and taking prescription drugs for their condition. The students were in grades three through 12. The total sample was 230 students. Students were administered an age- and grade-appropriate form of the Learning Style Inventory (LSI; Dunn, Dunn, & Price 1996). The first study examined the learning style of elementary students (grades 3-5) with ADHD, and the second study examined the learning styles of secondary school students (grades 5-12) with ADHD.

The elementary school study conducted by Brand et al. (2002) identified three elements that were significant ($p < .05$). Students in the study identified they preferred low light when learning. Students in this group were less persistent, and did not prefer to learn in the morning. The analyses revealed that these students were significantly ($p < .01$) more motivated by parental encouragement than regular education students. Brand et al. (2002) found that the ADHD students did not identify any of the elements that are normally associated with ADHD students as significant. They were not different from their peers in the elements of mobility and preference for kinesthetic learning. They were similar to their peers in perceptual preferences and had similar seating preferences.

When Brand et al. (2002) analyzed the data for gender differences, persistence and preference for auditory learning were significant ($p < .02$). Boys identified themselves as more

persistent than the girls. Girls preferred more auditory learning than the boys. They noted that more persistence in boys than girls, was unusual.

When the data were analyzed with grade level as a variable, statistical significance was revealed at the $p < .001$ level (Brand et al., 2002). There were differences between the third and fourth graders, and the fifth and sixth graders. The older students identified low light ($p < .001$), structure ($p < .005$), afternoon learning ($p < .014$), and motivation by teachers ($p < .026$) were the most significant elements and were different from the younger students. Based on the data, Brand et al. (2002) concluded that the learning styles of ADHD students may change more rapidly than would be expected from their peers. The researchers found this information interesting since they reported that this was in contrast to previously reported data that shows that teacher motivation decreases with grade level. Brand et al. (2002) reported that they found it was unusual to find a population with no preference for auditory, visual, tactual, or kinesthetic learning. Forty-six percent of the population reported no perceptual preference for learning. The students had no identifiable processing style (analytic or global). The researchers reported that this indicates that students would need to be highly interested in what is being taught in order to learn.

In the second study with secondary students with ADHD, Brand et al. (2002) examined the learning styles for students in grades five through twelve. Eight of the 12 elements were found to be significant ($p < .001$). Students in this group preferred learning in the afternoon, in a structured environment, having information presented in patterns, and using kinesthetic approaches. Significance ($p < .01$) was also found for learning tactually and being motivated by parents. These students had a significant negative visual score ($p < .05$) that was interpreted as a

dislike for learning by reading (Brand et al., 2002). The researchers noted that there was a subgroup within the ADHD group that did not have any learning style framework.

The data were analyzed to determine similarities and differences for gender. Only one of the 21 elements was found to be different, but there were no significant differences. Males had a stronger preference for kinesthetic learning than did the females. The results revealed that male and female ADHD students at these grade levels showed more similarities than differences in the way they learn (Brand et al., 2002).

Data were analyzed to determine similarities and differences for grade level. The results of the Analysis of Variance revealed significance ($p < .01$) that fifth and seventh grade students had a stronger preference for learning tactually than did the tenth grade students. When Brand et al. (2002) compared students as pre-high school (grades 5-8) and high school (grades 9-12), the analyses revealed 22 significant ($p < .05$) differences. In summary, the pre-high school students preferred learning with tactual and kinesthetic approaches. They preferred to have instruction presented in patterns, to have routines, and were motivated by parents and teachers. High school students showed preferences for increased lighting, conformity, and auditory learning (Brand et al., 2002). The studies and the results are presented in Table 1.

Table 1

Studies Using the Dunn and Dunn Learning Style Model

Researchers	Population	Study Examined	Findings
Braio, Beasley, Dunn, Quinn, and Buchanan (2001)	Special Education elementary students (n = 81) Low-achieving students (n = 35)	Incremental implementation of learning-style strategies, and effects on achievement in reading	Teaching SPED and low-achieving students through their learning-style preferences improved academic achievement.
Brand, Dunn, and Greb (2002)	Elementary ADHD Students (grades 3-6)	Learning-style preferences of students medically diagnosed as ADHD	Elementary students preferred soft lighting, frequent breaks, late morning, afternoon, or evening learning, and were motivated by parental encouragement.
	Secondary ADHD Students (grades 5-12)		Secondary students preferred learning in the afternoon, in a structured environment, information presented in patterns, and kinesthetic approaches.
	Total sample – 230 Students		information presented in patterns, and kinesthetic approaches.
Farkas (2003)	Urban 7 th grade regular education students (n = 105)	The effects of traditional versus learning-style instructional methods on students' achievement, attitudes, empathic tendencies, and transfer skills in Social Studies	Positive and statistically significant ($p < .001$) on achievement, attitudes, empathic tendencies, and transfer skills; Large effect sizes for each of the dependent variables.

(continued)

Table 1

Studies Using the Dunn and Dunn Learning Style Model

Researchers	Population	Study Examined	Findings
Fine (2003)	High school students (n = 422) for comparison of groups; Special education students with intervention (n = 14)	Determine learning-style similarities and differences between SPED and regular HS students; Determine which elements would produce the most significant gains in achievement, attitude, and behavior;	When learning-style strategies were introduced short-term and long-term ($p < .05$) improved; attitudes improved ($p < .05$); incremental improvements in behavior were seen as learning-style strategies were employed.
Friedlander (2010)	Students with Autism (n = 52) and typical elementary students (n = 60)	Learning styles of students with autism compared to typical elementary students	Students with autism showed commonality in 24 out of 25 preferences tested ($p < .025$). Four of the 25 preferences tested showed significant differences between the groups ($p < .025$).
Geiser, Dunn, Deckinger, Dening, Sklar, Beasley, and Nelson (2001)	Suburban 8 th grade students (n = 130)	Effects of learning-style awareness and responsive study strategies on achievement and attitudes in mathematics	Below-average achievers who applied learning-style responsive strategies had significantly higher achievement and attitude scores.

(continued)

Table 1

Studies Using the Dunn and Dunn Learning Style Model

Researchers	Population	Study Examined	Findings
Lister (2005)	Bermudian learning-support 6 th grade students	Effects of traditional versus tactual and kinesthetic learning-style responsive instructional strategies on achievement and attitude in social studies	Learning-support students significantly higher ($p < .05$) achievement and showed significantly more positive ($p < .05$) attitudes when learning-style approaches were used.
Lovelace (2005)	76 original research investigations; 7,196 participants	Meta-analysis of the experimental research	168 individual effect sizes; Increased achievement and improved attitudes when responsive instruction was available for diagnosed learning-style preferences.
Minotti (2005)	6 th – 8 th grade students (n = 167)	Effects of learning-style based homework prescriptions on achievement and attitudes	Students showed significance growth in academic achievement ($p < .001$), attitude toward homework ($p < .05$), and attitudes toward learning styles ($p < .001$).
Nunn (1995)	At-risk middle school students (n = 103)	Effects of a learning styles and strategies intervention	Significant improvement within the at-risk intervention group in grade point average and locus of control.

(continued)

Table 1

Studies Using the Dunn and Dunn Learning Style Model

Researchers	Population	Study Examined	Findings
Rayneri, Gerber, and Wiley (2003)	Gifted Achievers and Gifted Underachievers (n = 80)	Learning style needs of low-achieving gifted students when compared to high-achieving gifted students	Gifted underachievers differed in their strong preference for dim lighting and tactual methods, and were less persistent in completing tasks.
Schiering and Dunn (2001)	5 th grade science students Two classes (experimental and control)	Investigation of the relationships of metacognition, self-teaching, learning-style accommodations, and content learning	Students in the LS group performed significantly better on science knowledge and demonstrated more positive attitudes toward learning.

Research on the Dunn and Dunn Model has demonstrated that student achievement and attitudes were positively influenced by matching instruction with a student’s assessed learning style. This research study also investigated specific aspects of students’ perceptions of their assessed learning styles. The following section defines perception in the context of this study and pertinent research findings of students’ perceptions of the tactually-preferenced learning process.

Conclusion

John Dewey provided the theoretical foundation for learning styles. In his book, *Experience and Education* (1938), Dewey’s philosophy of education identified that learning is about the experiences of the learner. Dewey explained that a student’s learning is affected by his

or her individual needs, desires, capacities, and purposes, in relation to what is happening in the environment (pp. 43-44).

Gregorc, Kolb, and Dunn and Dunn explored the construct of learning style and how it could be accurately assessed. Gregorc's Mind Styles Model identified four different learning patterns – Concrete Sequential (CS), Concrete Random (CR), Abstract Sequential (AS), and Abstract Random (AR). Kolb's Learning Style Inventory is based on his Experiential Learning Model and identifies four different styles: concrete experience, abstract conceptualization, active experimentation, and reflective observation. Dunn and Dunn developed the Dunn and Dunn Learning Styles Model that can be assessed using age- and grade-appropriate instruments. The Dunn and Dunn Model is the most comprehensive and thoroughly researched model with valid and reliable assessments (Lovelace, 2005). The model identified the learning-style preferences across five stimuli – environmental, emotional, sociological, physiological, and psychological.

The research studies presented on the Dunn and Dunn Model provided substantial evidence that when students were matched with their individual learning-style preferences, they were able to demonstrate increased academic achievement, better attitudes toward learning, and increased behavior (Lovelace, 2005). The studies demonstrated that student learning-style preferences can be used with all students and disciplines (Braio et al., 2001; Farkas, 2003; Fine, 2003; Geiser et al., 2000; Lister, 2005; Schiering & Dunn, 2001). When learning-style preferences are identified for specific classifications of students (at-risk, low-achievers, ADHD, gifted, special education), the same results were documented for achievement, attitudes, and behavior (Braio et al., 2001; Brand et al., 2002; Fine, 2003; Geiser et al., 2000; Lister, 2005; Nunn, 1995; Rayneri, 2003). Studies that involved perceptual preferences, specifically tactual and kinesthetic modalities, found that students showed statistically significant growth with short-

term and long-term academic achievement and attitudes toward learning improved. Students in these studies showed increased attitudes toward learning styles (Braio et al., 2001; Brand et al., 2002; Fine, 2003; Lister, 2005; Minotti, 2005; Schiering & Dunn, 2001; Rayneri, 2003). Based on the research presented, it can be concluded that individuals have unique learning styles and the sub-groups often identified as underachievers, also have unique learning styles that often do not match the instructional methods of a typical traditional classroom.

CHAPTER THREE: METHODOLOGY

This chapter describes the research design and methodology of this study, which was designed to determine the similarities and differences in the learning-style preferences of fifth grade students achieving Adequate Yearly Progress (AYP) and fifth grade students not achieving Adequate Yearly Progress (non-AYP) in mathematics. The study was also designed to determine the significant learning-style preferences of the students not achieving adequate yearly progress in mathematics. This study investigated the ways that tactually-preferenced, non-AYP students use their learning-style profile to design instructional strategies that facilitate learning and how they perceive using their learning-style strategies. The following information will be presented in this chapter relevant to the research methodology: researcher's biography, research questions and hypotheses, description of the setting and subjects, research design, description of the instruments, description and justification of the analyses, data collection procedures, limitations of the study, and ethics statement.

Researcher's Biography

In the exploratory sequential mixed method design, qualitative research is conducted in the second phase. In this study, participant interviews and a focus group were used as a method of collecting data. The researcher performed this role in the process. An emic approach was used to capture the thoughts and perceptions of the students involved using their words. The data were evaluated from a professional perspective, or etic approach, to present a broader meaning through themes, patterns, and concepts (Gall, Gall, & Borg, 2011).

The researcher completed 30 years of classroom experience as a special education teacher working with students from kindergarten through the sixth grade level. In addition to her classroom experience, she is a National Board Certified Teacher for Students with Exceptional

Needs and attended the International Learning Styles Institute. She has completed the requirements for intermediate level administration and supervision.

The researcher is a trained observer of students and is able to concisely describe educational achievement, physical, and social development necessary for Individualized Education Plans. As a special education teacher, the researcher has accurately identified student needs and prescribed appropriate learning situations. The researcher has maintained diagnostic notes, administered assessments, and interpreted data in her teaching role. The researcher has worked with children of this age group and understands the developmental levels of the participants in the study, and is knowledgeable of the mathematics curriculum content.

Coursework and practice in the doctoral program trained the researcher in the proper procedures for conducting a mixed method study. The researcher was aware of possible bias that could affect the analysis of the data in this research. She has had training in learning styles and used responsive learning-style strategies as a method in her classroom. The researcher attempted to minimize bias by considering alternative explanations and maintaining an awareness of possible preconceived views. The researcher has completed an in-depth review of the literature and consulted with an advisor and peers. Transcribed and coded interviews, student portfolios, and self-reflection data were triangulated and an audit of the data was conducted.

Research Questions and Hypotheses

This study addressed the following questions:

Research Question One: Are there differences between the learning-style preferences of fifth grade students not achieving adequate yearly progress and the learning-style preferences of fifth grade students achieving adequate yearly progress in mathematics?

Hypothesis: There will be differences between the learning-style preferences of fifth grade students not achieving adequate yearly progress and the learning-style preferences of fifth grade students achieving adequate yearly progress in mathematics.

Research Question Two: Are there common learning-style preferences among fifth grade students who are not achieving adequate yearly progress in mathematics?

Hypothesis: There are common learning-style preferences among fifth grade students who are not achieving adequate yearly progress in mathematics.

Research Question Three: In what ways do tactually-preferenced, non-AYP fifth grade students use their learning-style profiles to design instructional strategies that facilitate learning?

Research Question Four: What are the perceptions of tactually-preferenced, non-AYP fifth grade students when using tactual learning-style strategies?

Description of the Setting and Subjects

The site of this study was a rural New York State school district with a population of 1,560 students. The elementary school (grade 3-5) in this study has a population of 323 students in grades three, four, and five. The free or reduced lunch eligibility rate in this school is 48%. The average class size is 23 students. The elementary school one administrator (principal) and the teaching staff includes 14 classroom teachers, two self-contained special education teachers, three grade level special education teachers that provide direct instruction in English Language Arts and team teach mathematics, two remedial reading specialists, a full-time psychologist, and five special area teachers (art, physical education, library, healthy living, and music). A full-time remedial math position has been eliminated. All teachers have a master's degree with more than five years of teaching experience. The support staff includes five teaching assistants, three aides, two monitors, and a school nurse.

Additional math support had been offered after school twice a week for approximately 45 minutes for students in need of extra support. This support was eliminated when the data showed no increase in achievement scores. A computer software program that is linked to individual student testing has been implemented. Teachers have been instructed to use this program for mathematic support during the weekly 40-minute computer time. The school's demographics are presented in Table 2.

Table 2

Demographic Data of School Population

School Population by Demographic	Number
All Students	323
Female	158
Male	165
American Indian or Alaskan Native	0
Black or African American	21
Hispanic or Latino	56
Asian or Native Hawaiian/Other Pacific Islander	8
White	230
Multiracial	8
General Education Students	275
Students with Disabilities	48
English Proficient	315
Limited English Proficient	8
Not Economically Disadvantaged	168
Economically Disadvantaged	155

Adequate Yearly Progress (AYP) indicates satisfactory progress by a district or a school toward the goal of proficiency for all students measured by comparing the percentage of students tested and the performance of tested students against defined standards. A district is determined to have made Adequate Yearly Progress (AYP) if they reach an annual target for improvement based on performance indicators and accountability of sub-groups (race/ethnicity, English Language Learners, special education, etc.) using the number of assessments for evaluation (New York State Education Department, 2012). The district has not met AYP for Students with Disabilities and Economically Disadvantaged subgroups according to New York State accountability requirements. Focused Accountability status had been implemented because AYP was not attained in two or more groups as presented on the 2010-2011 School Report Card (New York State Education Department, 2012). The cohort group, Students with Disabilities, has not attained proficiency for two consecutive school years (2009-2010 and 2010-2011; New York State Education Department, 2011). These classifications by the state prompted a program evaluation that was conducted during the 2011-2012 school year by the local Board of Cooperative Educational Services specialists. Recommendations were made to the district in the final report. Recent changes to the format of the School Report Card present this information differently, nonetheless both Economically Disadvantaged students and Students with Disabilities statistics continue to remain below the state's suggested expectations for adequate yearly progress.

This research investigated the learning-style preferences of 108 fifth-grade students that were currently enrolled in the district and had data available from the New York State Mathematics Assessment. Fifty-four of these students did not achieve AYP and 54 achieved

AYP on the assessment. AYP has been determined by the scores on the New York State Assessment in Mathematics by achieving a Level 3 or Level 4. These students were a sample of convenience and learning style data was obtained through the assessment that was part of the grade level assessments. The similarities and differences between the groups were analyzed, and the preferences of the non-AYP were determined. The demographic data for the grade level is presented in Table 3.

Table 3

Demographic Data of 5th Grade Population

5 th Grade Population by Demographic	Total Tested	Non-AYP		AYP	
		Number Scoring at Levels		Number Scoring at Levels	
		1	2	3	4
All Students	108	11	43	47	7
Male	59	7	19	29	4
Female	49	4	4	18	3
General Education	86	3	33	43	7
Students with Disabilities	22	8	10	4	0
American Indian or Alaskan Native	1*				
Black or African American	6*				
Hispanic or Latino	17	3	7	6	1
White	82	8	31	37	6
Multiracial	2*				
Students with Disabilities	22	8	10	4	0
English Proficient	106				

(continued)

Limited English Proficient	2*				
Not Economically Disadvantaged	59	4	26	25	4
Economically Disadvantaged	49	7	17	22	3

*Insufficient numbers to report as an accountability group. An accountability group must have 40 or more members with 95% tested. Accountability group is based on total registered students for the school.

Based on the results of the learning-styles assessment, ten students from the fifth-grade group of 108 were identified for the qualitative component of this study. These ten students met the following criteria:

1. Student has not achieved AYP as documented by their score on the New York State Assessment in Mathematics (Level 1 or Level 2),
2. Primary learning-style preference is tactual as measured by the learning-style assessment.

Six students from the initial group agreed to participate in the study. The six students had Performance Levels of 1 or 2 on the New York State Assessment in Mathematics for both third and fourth grades. Assessment scores at Performance Level 1 indicate that a student is well below state standards and considered to be insufficient for the grade level. Assessment scores at Performance Level 2 indicates that a student is partially proficient in the state standards, but at an insufficient level for the grade level. All of these students were considered to have average ability and were not identified as a Title 1 student or a Student with a Disability. The results of the Learning Style: Clue to You! (LSCY; Burke & Dunn, 1998) indicated that these students had a strong preference for tactual learning.

Research Design and Data Analyses

An explanatory sequential mixed method design was used for this research study. This research design had two phases, quantitative and qualitative. Creswell and Plano Clark (2011) explained that the designs starts with a quantitative collection of data that serves as the primary source of information to address the research questions. During the qualitative phase, data are gathered to help explain the quantitative results. This research design allowed the researcher to interpret "...to what extent and in what ways the qualitative results explain and add insight into the quantitative results and what overall is learned in response to the study's purpose" (p. 83). The research design is presented in Figure 2.



Figure 2. Description of the Explanatory Sequential Design. Adapted from “Prototypical Versions of the Six Major Mixed Methods Research Designs,” by J. W. Creswell and V. L. Plano Clark, 2011, *Designing and Conducting Mixed Methods Research*, p. 69. Copyright 2011 by Sage Publications, Inc.

Quantitative data for Research Question One and Research Question Two were collected from the results of the LSCY. This instrument assessed the primary construct of learning-style preferences of the fifth grade students, both AYP and non-AYP. The data collected from the LSCY for Research Question One were analyzed using a Chi-square Two Variable Crosstabulation table examining each of the 22 learning-style variables for each of the two groups, AYP students and non-AYP students. These data were analyzed to determine the similarities and differences in learning-style preferences of both AYP and non-AYP groups.

The data for Research Question Two were analyzed using a Chi-square Goodness of Fit test to examine the differences in the categorical data (learning-style preferences) for non-AYP students. The analyses of the learning-style preferences of the non-AYP students were used to determine the significant learning style-preferences of the underperforming students.

The criteria for inclusion in the second phase of the study were determined by the data from the LSCY. Ten non-AYP students with a strong preference for tactual learning were initially identified for phase two. Six students agreed to participate in the study.

The second phase of this design is to collect qualitative data. Research Question Three and Research Question Four were designed to explain and elaborate upon the qualitative data collected from interviews, a focus group, and a student portfolio. The researcher collected qualitative data from students to triangulate and examine these data for patterns, similarities, and differences in context of results obtained with the LSCY. The qualitative data was used to answer Research Question Three and Research Question Four. In this phase, the six students attended two training sessions on learning styles. They were given a portfolio to keep their learning style information, learning logs and self-reflections, and a reference section of tactual learning resources. The portfolios were collected at the end of the study. The students were interviewed and transcripts were member checked with the researcher. A focus group was conducted at the end of the study to provide the participants an opportunity to share their experiences and perceptions. The session was transcribed and these data were coded and analyzed.

Instrumentation

In an explanatory sequential design method both quantitative and qualitative data are collected and analyzed. In this study, the following instruments were used: the LSCY, student

portfolios, semi-structured interviews, a focus group, a reflexivity journal, and student-created artifacts. This section will identify the purpose of each instrument.

Learning Style: The Clue to You!

The fifth grade students had been administered the instrument Learning Style: The Clue to You! (LSCY; Burke & Dunn, 1998) as part of routine school district procedure. The LSCY is a comprehensive diagnostic tool that reveals a student’s full spectrum of learning-style preferences. LSCY measures a student’s learning-style preferences through five different strands or stimuli. These include environmental, emotional, sociological, psychological, and physiological. A complete description of the strands were presented in Chapter 2 and are summarized in Table 4.

Table 4

Dunn and Dunn Learning Style Model Strands and Elements

Strands	Elements
Environmental	Sound, Light, Temperature, Seating
Emotional	Motivation, Persistence, Responsibility, Structure
Sociological	Working: Alone, Pair, Peer, Group, Authority, Variety
Physiological	Perceptual: Auditory, Visual, Kinesthetic, Tactile; Intake, Time of Day, Mobility
Psychological	Analytic – Global Impulsive – Reflective

The LSCY requires students to complete 69 questions that are used to identify their particular learning-style preferences through an online assessment that takes approximately 40 minutes to complete. The assessment is presented in five sections introduced through a high

interest detective stories and is followed by a series of questions. Questions are repeated three times throughout the assessment to assure consistency in the student's responses. These questions are presented with a picture and a written word so students are able to respond using their preferred preference. Scoring is completed by summarizing the preferences for each of the five stands. A one-page profile is produced depicting the individual learning-style preferences of the student. A full narrative report that includes detailed information on the individual's learning-style preferences is generated to assist with interpretation and provide examples of how to implement the findings (Dunn & Burke, 2005-2008). Scoring that indicates a student has a "strong preference" for a learning-style element always has that preference, while a score that indicates "preference" indicates this is the student's usual selection for this element. For example, a student with a strong preference for informal seating would always make this choice and a student with a preference for informal seating would usually make this choice. Students may also choose "it depends" indicating no preference or it is conditional to the situation. A sample question is provided in Figure 3.

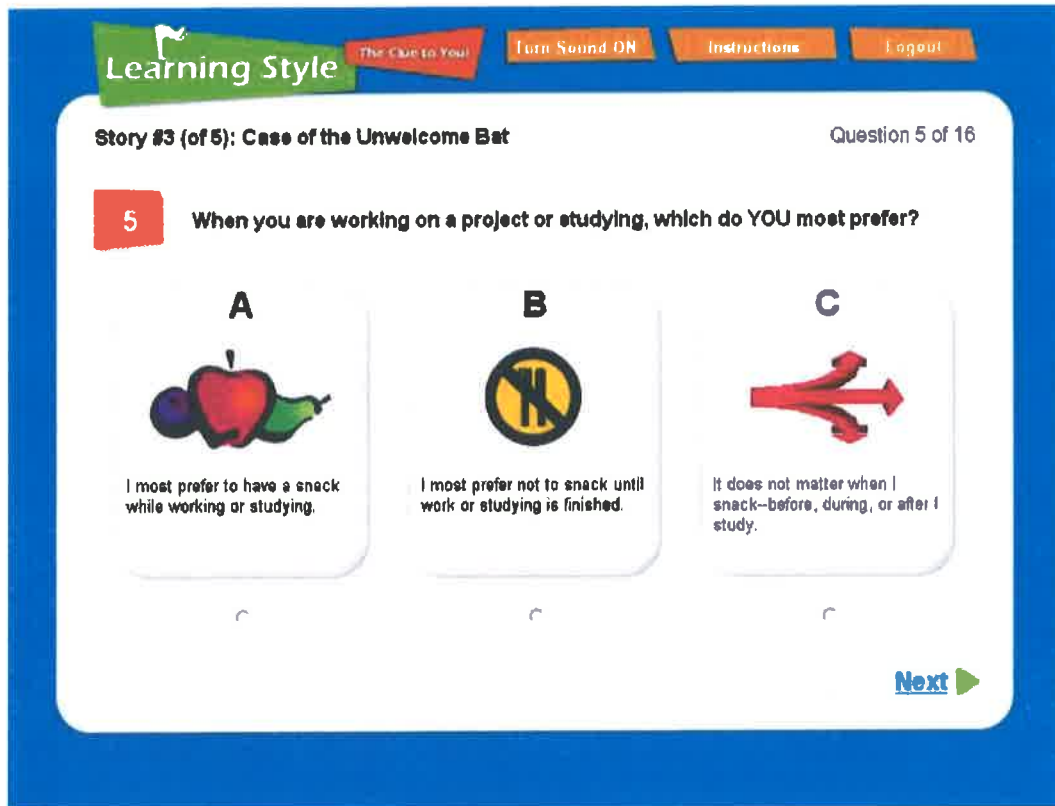


Figure 3. Adapted from “LSCY: Research and Implementation Manual,” by R. Dunn, and K. Burke, 2005-2006, p. 11. Copyright 2005-2008 by Dunn & Burke.

The research for validity and reliability for the LSCY was conducted on 534 sixth, seventh, and eighth graders in a variety of educational institutions and located in major geographic locations in the United States, including urban, suburban, and rural areas. The sample population included 270 females and 264 males representing diverse ethnicities (Burke & Dunn, 1998).

Content validity was established by a five-member jury that examined, and unanimously agreed that the LSCY paralleled the Dunn and Dunn Learning-Style Model, incorporated 20 elements of that model. The jury found that the LSCY conformed to established criteria for the assessment of learning styles, contained appropriate content for middle-school students, and

conformed to established criteria describing a global cognitive style (Dunn & Burke, 2005-2008).

A test-retest reliability coefficient for each element of the LSCY was computed. Test-retest reliability coefficients ranged from a minimum of .727 (visual) to a maximum of .994 (light). The mean value of the coefficients was .937. The high test-retest reliability demonstrates that an individual's test results will remain consistent with repeated administrations (Dunn & Burke, 2005-2008).

Internal-consistency reliability was established by computing Cronbach's Alpha to determine correlation coefficients among items within each element. The LSCY coefficients ranged from .76 to .99 with a mean of .94. A higher coefficient indicates that test takers that answer items one way will respond in a similar way on other related items (Gall, Gall, & Borg, 2007).

Training Procedures

Ten students met the criteria of being non-AYP and had a strong preference for tactual learning. Each student received information about the study, and from that group, six students agreed to participate in the study. The training sessions were scheduled after permission from the parents and an assent from the students were obtained. The six non-AYP students with a strong preference for tactual learning attended the training sessions after school. The students met two times for 60 minutes to learn about learning styles, their tactual preference for learning, and how to create and use tactual learning-style strategies for mathematics.

At the first meeting, students were presented with a portfolio that contained the one-page learning style profile and the complete learning style profile with comprehensive learning-style responsive strategies. A PowerPoint presentation about learning-style awareness was used to

introduce the construct of learning style. A focus on tactual learning was included to introduce the students to learning in their preferred style through hands-on materials and manipulatives as their primary perceptual preference. The students were introduced to the use of tactual materials, and how these materials could facilitate their learning in mathematics.

At the second session, learning styles and tactual preferences were reviewed through a second PowerPoint presentation. The students were shown previously made tactual materials and had the opportunity to use them. The students had the opportunity to create tactual materials that were suggested by the researcher to prepare for the next chapter test in mathematics. The choices included an Electroboard, Flip-Chute, or Learning Circle. All the materials needed were prepared and provided by the researcher. Students were encouraged to take home the portfolio with the learning style profile, and the tactual resources. The portfolio contained a section that included additional information on other tactual materials and how to create them (Burke, n.d.). Students were told that resource materials that may be needed throughout the study would be stored in the researcher's classroom where each of the students had access during the school day and after school. The researcher informed the students who she would be available every Tuesday after school and on other days if they made an appointment.

Portfolio

The six students maintained a student portfolio divided in to three sections. The three sections included the 1) learning style training PowerPoints and LSCY profiles; 2) learning logs; and 3) chapter mathematics assessments with self-reflection sheets (see Appendix A). The portfolios were maintained by the students and were collected at the end of the study.

Student reference section. The first section of the portfolio contained the training PowerPoints. Section 1 also included the individual one page profile and the full narrative report

from the LSCY (see Appendices B and C). The tactual materials booklet was provided as an additional resource (Burke, n.d.).

Learning log. Students maintained a log that included the math chapter objectives. Students documented the strategies used for learning, and how useful these strategies were for learning the chapter objectives (see Appendix D). They rated each activity based on a 1-5 scale with 1 being “not at all” and 5 being “very much”.

Self-Reflection. The third section included the self- reflection checklist where the student documented their math achievement on the chapter tests, and their perceptions on the use of the learning-style strategies. A student friendly protocol focused on tactual learning-style strategies used for collection of qualitative data. The document was written with “I can” statements focusing on the math chapter objectives. The self-reflective checklist was attached to the regular summary used for math chapter tests (see Appendix E). The information collected focused on the individual student’s preferred tactual style and whether or not it was used to prepare for the math assessment. Students documented their satisfaction or dissatisfaction with their score on the assessments when they indicated a positive or negative reaction and a reason to support their perception on the self-reflection checklist. The checklists for chapter posttests were collected according to the fifth grade class testing schedule.

Semi-structured Interviews

Six students individually met with the researcher for three interviews. The interviews were recorded and all data were transcribed. The researcher documented the sessions with written notes on a prepared protocol. Students were contacted by the researcher to schedule the interviews. The interviews were conducted in the researcher’s classroom and were approximately 15-20 minutes in length. Students had the opportunity to review the transcriptions

of the interviews. Member checking was completed for validity of the data. HyperRESEARCH 3.7.1 (Researchware, Inc., 2014), a data analysis program, was used to code and identify patterns and themes.

The interviews were semi-structured with guided questions reflecting the student's knowledge of their learning style, the use of learning-style strategies and implementation of the tactual strategies (see Appendix F). The protocol guided the interview and maintained continuity. In some cases, probing questions were added to further explore a student's response. There was also an opportunity for students to ask questions or clarify the information about their profile, learning style, or the strategies. The student interviews were used to gain an understanding of student perceptions pertaining to their knowledge of their individual learning style and the implementation of tactual learning-style strategies.

Focus Group

A focus group was conducted at the end of the study to review the process with the six students, explore their perceptions, and hear their feedback about learning styles and the strategies they implemented during the study. The protocol had semi-structured questions guiding the group toward reflections on the process of using learning-style strategies, and their plans for using them in the future (see Appendix G). The focus group was recorded and transcribed. The researcher documented the session with written notes.

Reflexivity Journal

The researcher maintained a reflexivity journal that documented dates that were important to the study, student profile information, description of activities, and meetings that were initiated by the participants. The PowerPoints and notes were included on the learning

style training sessions. The journal provided a framework to review events, conversations with participants, and the reflections made by the researcher.

Artifacts

The researcher photographed and collected examples of the tactual materials. Wrap Arouns, Electroboards, Learning Turnovers, and Flip Chutes, were created as part of the training sessions. During the course of the study additional materials were made and documented. Some materials were created from pre-printed prepared materials available during the resource times. Complex examples of tactual materials included student created lessons and games. Examples of the materials are presented in Figures 4 - 11.

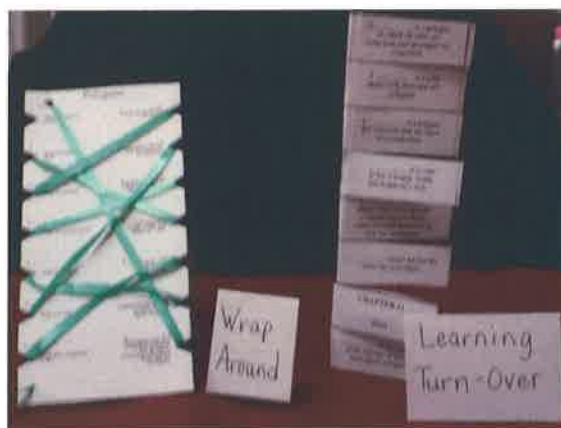


Figure 4. Wrap Around and Learning Turn-Over created during training sessions.

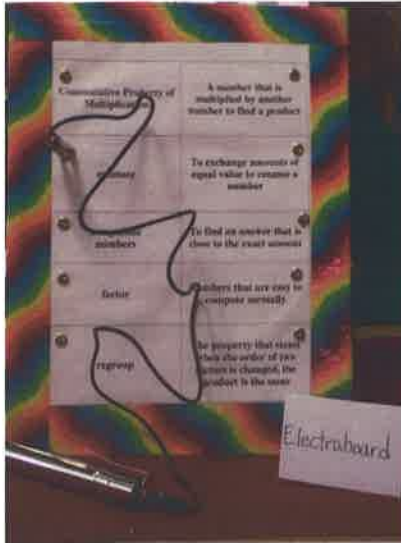


Figure 5. Electroboard created during training sessions.

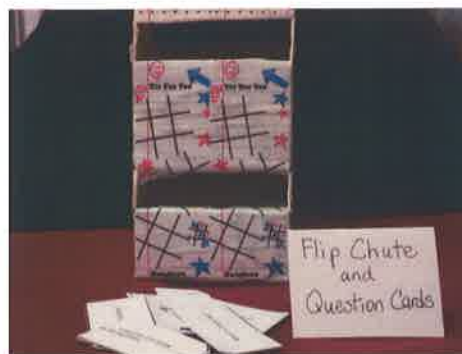


Figure 6. Flip Chute and Question Cards created during training sessions.

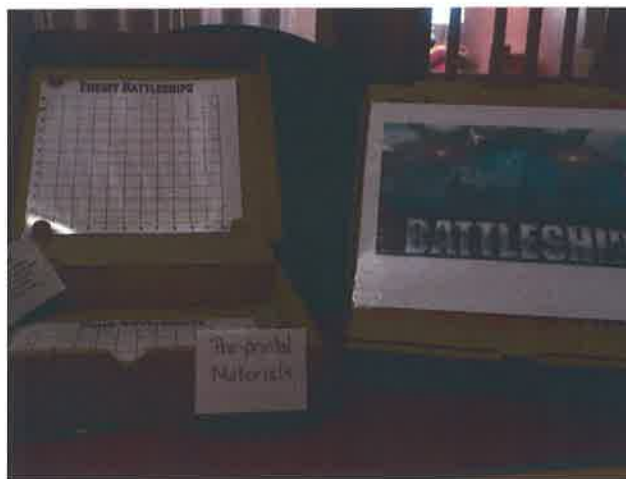


Figure 7. Battleship - example of pre-printed tactual materials created by students.



Figure 8. Volume Victory - example of complex student materials created with assistance.



Figure 9. Number Pattern Twister - example of complex student materials created with assistance.



Figure 10. Coordinate Graphing of Geometric Shapes floor game - example of complex student materials created with assistance.



Figure 11. Racing Ratios - example of complex tactual materials created independently.

Description and Justification of the Analyses

The data for Research Question One were analyzed using a Chi-square Two Variable Crosstabulation examining each of the 22 learning-style variables for each of the two groups, AYP students and non-AYP students. A Chi-square Two Variable Crosstabulation is an appropriate nonparametric statistical test to determine if significant differences exist beyond the .05 level in two groups in examining whether AYP students have specific learning-style preferences (Huck, 2008). The Statistical Package for the Social Sciences 18.0 (SPSS) was used to analyze the data collected.

The data for Research Question Two were analyzed using a Chi-square Goodness of Fit test to examine the differences in the categorical data (learning-style preferences) for non-AYP students. This nonparametric statistical test was an appropriate measure to determine if the frequency counts were distributed differently for this sample (Gall, Gall, & Borg, 2011). The Chi-square analysis was used to determine if there is a significant difference in the sample beyond the .05 level between the observed data and the expected data (Huck, 2008).

For Research Questions Three and Four, qualitative data were collected through recorded student interviews and a focus group, and the student portfolios. These data provided detailed documentation along with artifacts of the study. The qualitative analyses were aimed at using the individual voices of the students to better understand the perceptions of using tactual learning-style preferences for learning. All interviews were transcribed and member checking was used with the students' transcripts to ensure their statements were reported accurately. Initially, hard copies of the transcripts were coded by hand to become familiar with the data. The transcripts were imported into HyperRESEARCH 3.7.1 (Researchware, Inc., 2014) to aid in the process of coding and analyzing the interview data. Initial coding began with a list of

provisional codes which were subject to modification and adjustment based on the data (Saldaña, 2013). Axial coding was conducted in the second cycle to group the coded themes and eliminate marginal or redundant data. Axial coding is used to move from the initial coding of the data by allowing the data set to be reorganized to focus on the items that most clearly explain the phenomenon. The common themes and patterns that emerged explain the experiences of the study participants related to Research Question Three and Research Question Four. An auditor reviewed the transcripts and confirmed that the accounts are an accurate representation of the experiences.

Data Collection and Timeline

The study took place between October 2013 and June 2014. An application was made to the Institutional Review Board (IRB) of Western Connecticut State University. The study was approved by the IRB in October 2013.

Permission was granted by the Superintendent of Schools and the Building Principal in January 2014. Students were then selected for the study based on the results of the LSCY and their performance on the New York State Mathematics Assessment. In January, the researcher met with the 10 students to explain the study and ask for their participation. The researcher contacted the parents and guardians prior to sending home permission slips to provide an explanation of the study and as an opportunity for the adults to get to know the researcher's background. Parental permission slips and student assent forms were sent home. Six sets of completed forms were received by January 31, 2014.

Two training sessions on learning styles were held in March 2014. Individual interviews were conducted from April through June. The focus group was held on June 13, 2014 and

student portfolios were collected from all six students at that time. The timeline is presented in Table 5.

Table 5

Study Timeline

Date	Action
September 2013	Submission to Institutional Review Board (IRB) for approval
October 2013	IRB approval
January 2014.	Superintendent’s approval to conduct the study in the district Principal’s approval to conduct research at the school
January 2014	Parental permission and student assent forms collected
March 4, 2014 and March 11, 2014	Student training sessions
April – June 2014	Students interviews
June 13, 2014	Focus group and portfolios collected

Limitations of the Study

A sequential explanatory mixed method research study faces potential threats to validity. The potential threats to validity in a mixed-method design are related to data collection, data analysis, and interpretation (Creswell & Plano Clark, 2011).

Internal Validity

In the quantitative research, Creswell and Plano Clark (2011) write that the researcher should be concerned with “the quality of the scores from the instruments used and the quality of the conclusions that can be drawn from the results of the analysis” (p. 210). Potential threats to internal validity in respect to these concerns are addressed below.

Testing. All students were tested with the same valid and reliable instrument measuring learning style. All the learning-style assessments were administered by the researcher who followed the protocol so there were uniform testing situations. The determination of AYP or non-AYP was taken from the New York State Assessment data for the school district.

Instrumentation. The LSCY was used to measure the construct of learning style is a valid and reliable instrument. Content validity, test-retest reliability, and internal-consistency reliability have been measured, and the analysis is available in the manual (Dunn & Burke, 2005-2008). The LSCY was selected as an appropriate measure of learning style for students in this study.

Statistical Analysis. The statistical analyses for Research Question One and Research Question two were completed using SPSS 18.0. A Chi-square Crosstabulation and Chi-square Goodness of Fit tests were used for the data analyses. A Bonferroni correction was used to reduce the chances of a Type 1 error when multiple pair-wise comparisons are performed on a single set of data. An alpha level of .025 was set.

External Validity

External Validity applies to the extent that the results can be applied to other populations. Inferences taken from the data can only be made if the researcher correctly identified a representative sample (Gall, Gall, & Borg, 2011). Potential threats to external validity are addressed below.

Population. This study had a small subject size and conducted in a rural school district. A thorough description of the setting and subjects has been provided. It would be expected that similar districts would be able to make generalizations based on the data supplied. Currently, in

New York State similar rural school districts are experiencing comparable results in mathematics with AYP and non-AYP students (New York State Education Department, 2014).

Ecological. Complete and thorough information was provided on the instrument used in the study, and is readily available from the Learning Style website.

Trustworthiness

Trustworthiness is essential in a qualitative study. According to Lincoln and Guba (1985) trustworthiness is established through credibility, transferability, dependability, and confirmability. In this study, the researcher was collecting and analyzing data, and making interpretations, therefore, the four practices will be addressed.

Credibility is established when the researcher describes and interprets the data accurately (Lincoln & Guba, 1985). Threats to credibility were addressed through triangulation of data drawn from several sources, member checking, and the review of data by an outside auditor. The auditor was an experienced administrator and has her doctorate in Instructional Leadership. The auditor's report is included in the appendices (see Appendix M.) The researcher addressed any bias that may be connected to the work in the Researcher's Biography. The length of the study allowed the researcher to develop a relationship with the participants that permitted them to feel comfortable sharing their honest responses during the interviews and focus group.

Transferability refers to the application of the research to another group (Lincoln & Guba, 1985). A threat to this study is the small subject size and the setting of the research. The researcher provided a thorough description of the participants, setting, and the methods employed in obtaining the data. Potential users of the research would have to determine if the study is applicable to another group.

Dependability is demonstrated when both the process and the product is examined by another researcher and the findings and interpretations can be supported by the data (Lincoln & Guba, 1985). This threat has been addressed by identifying specific research questions to be addressed in the study and coding the data as it applies to these questions. An outside auditor reviewed the coding process of the researcher, and has established that the analyses can be supported by the data (see Appendix M).

Confirmability is established when the researcher remains neutral and presents the findings based on the participants in the study (Lincoln & Guba, 1985). This threat was addressed by creating an audit trail of the data and maintaining accurate records during the study. This study provided evidence from multiple sources. The data were reviewed by an outside auditor that confirmed the results.

Ethics Statement

IRB approval was obtained through Western Connecticut State University to conduct the study. The superintendent and the elementary school principal were provided a complete outline of the study and the researcher received permission to proceed with the study (see Appendices I and J). The researcher contacted parents and met with students to explain the study and to ask for participation in the study. Parental permission forms allowing the student to participate in the tactual training and interviews were obtained (see Appendix K). Students signed an assent form for participation (see Appendix L). Students selected pseudonyms for the study and confidentiality was maintained by the researcher. All data and information collected by the researcher were stored in a secure location that was accessible only to the researcher and the auditor.

Summary

This chapter described the methodology used in this exploratory mixed method study. The researcher included her biography and any bias was addressed. The research questions and hypotheses were presented along with a description of the setting and the subjects. The research design was explained, followed by the instruments utilized, and a description and justification of the analyses used in the study. The chapter provided the limitations of the study and an ethics statement. The next chapter will cover the detailed analyses of the data and explanations of the research.

CHAPTER FOUR: ANALYSIS OF DATA AND EXPLANATION OF THE FINDINGS

The purpose of this mixed method study was to determine the learning-style preferences of fifth grade students who achieve adequate yearly progress in mathematics and those who do not achieve AYP. The study also investigated the student use of tactual learning-style preference strategies and the perceptions of these students in the use of tactual learning. This study addressed the following questions:

Research Question One: Are there differences between the learning-style preferences of fifth grade students not achieving adequate yearly progress and the learning-style preferences of fifth grade students achieving adequate yearly progress in mathematics?

Hypothesis One: There will be differences between the learning-style preferences of fifth grade students not achieving adequate yearly progress and the learning-style preferences of fifth grade students achieving adequate yearly progress in mathematics.

Research Question Two: Are there common learning-style preferences among fifth grade students who are not achieving adequate yearly progress in mathematics?

Hypothesis Two: There are common learning-style preferences among fifth grade students who are not achieving adequate yearly progress in mathematics.

Research Question Three: In what ways do tactually-preferenced, non-AYP fifth grade students use their learning-style profiles to design instructional strategies that facilitate learning?

Research Question Four: What are the perceptions of tactually-preferenced, non-AYP fifth grade students when using tactual learning-style strategies?

The results of this research are presented in this chapter. The data collected from the tool used to measure learning-style preferences are presented, along with the qualitative findings based on learning style training, student interviews, and anecdotal observations.