The Identification of Gifted Students with Spatial Strengths: An Exploratory Study

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Abstract

Gifted students with spatial strengths are often overlooked and underserved in American schools. These students have areas of remarkable talent but often have verbal learning difficulties that prevent them from being identified for gifted services as traditional assessments emphasize verbal and quantitative skills, not nonverbal expertise. The dwindling number of American students pursuing higher level degrees in mathematics and science, natural strength areas for students with spatial skills, emphasizes the reasons educators need to identify and encourage these students at an early age.

This exploratory correlational research investigated the practicality and effectiveness of identification tools intended to locate elementary children with spatial strengths. *My Thinking Style (MTS)*, a self-report survey instrument, was developed for this research. The results of the survey, determined through one-on-one interviews with fourth grade students, were compared to performance on the *Naglieri Nonverbal Ability Test (NNAT)* and the block design subtest of the *Wechsler Intelligence Scale for Children-Fourth Edition (WISC-IV).*

Performance on a measure of nonverbal ability, the *NNAT,* was not related to visual-spatial ability as measured by the block design subtest of the

WISC-IV. Performance on the block design subtest was statistically significantly related to learning style preference as indicated on *MTS.* There was not a significant relationship between the *MTS* and the *NNAT.* The block design subtest of the *WISC-IV* has been shown to identify students with spatial strengths. The *Naglieri Nonverbal Ability Test* may not be effective in identifying children with spatial strengths, while the self-report instrument, *My Thinking Style* has potential to do so. The block design must be administered individually to students by a licensed professional, while *MTS* has the potential for quick and simple administration by any educator.

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CHAPTER 1

INTRODUCTION AND OVERVIEW OF THE RESEARCH

Introduction

This chapter describes the concept of visual-spatial learners, discusses the need to foster spatial strengths in high ability students, and provides an overview of this research study. Evidence of creative productivity in individuals with spatial strengths and sequential weaknesses provides support for the justification for the need for this research.

Albert Einstein, Auguste Rodin, Thomas Edison, Pablo Picasso, and Leonardo daVinci all made significant contributions to society, but evidence suggests that they may have had substantial learning difficulties in childhood (Dixon, 1983; West, 1997). These individuals' learning difficulties seemed to revolve around sequential activities that were areas of weakness, but their subsequent careers required them to use their extraordinary spatial strengths. Edison was considered "dull" by his teachers; Einstein did not speak until the age of 4; Rodin's work in school convinced his father that he was uneducable; daVinci is well known for his mirror writing; and Picasso had such difficulty with reading and writing that instead he spent his time in school drawing (Dixon). The mediocre classroom performance of these individuals masked their superior spatial abilities. Had these creative individuals failed to find an avenue to follow and a venue in which their talents were valued, their gifts to society might have been lost.

In a letter to a colleague, Albert Einstein answered questions regarding his thought process:

> The words or the language, as they are written or spoken, do not seem to play any role in my mechanism of thought. The psychical entities which seem to serve as elements in thought are certain signs and more or less clear images which can be "voluntarily" reproduced and combined….The above mentioned elements are, in my case, of visual and some of muscular type. Conventional words or other signs have to be sought for laboriously only in a secondary stage….In a stage when words intervene at all, they are, in my case purely auditive, but they interfere only in a secondary stage as already mentioned. (Hadamard, 1945, p. 142)

Verbalization played a secondary role in Einstein's thinking and was not integral in the process of developing new concepts. A theory of information processing determined that individuals process information in one of two ways, verbally or nonverbally. The verbal processing system manages abstract information in a sequential and successive manner. The nonverbal system processes information in a synchronous, simultaneous manner (Branoff, 1998). The educational system in the United States encourages the development of the verbal processing system and often neglects the nonverbal processing system which encompasses spatial reasoning ability.

Statement of the Problem

The traditional American educational system focuses primarily on verbal skills, rarely emphasizing the development of spatial skills. Many of the tests used to identify gifted students or judge achievement in students value performance speed over the careful and reflective thinking which is characteristic of learners with spatial strengths (Gallagher & Johnson, 1992). For example, college admission tests (such as the *Scholastic Aptitude Test* (*SAT*) and the *Graduate Record Exam* (*GRE*)) are traditionally used to determine entrance to undergraduate and graduate programs but do not assess spatial ability (Gohm, Humphreys, & Yao, 1998). The emphasis on mathematical and verbal abilities on college admissions tests and other high stakes testing may cause high school personnel to emphasize these areas when teaching and advising students (Gohm et al.).

Occupations that rely on spatial reasoning such as engineering, cartography, architecture, physics, chemistry, and medical surgery are associated with cognitively demanding educational tracks (Gohm et al., 1998; Humphreys, Lubinski, & Yao, 1993; Shea, Lubinski, & Benbow, 2001). The presence of spatial ability provided unique information for predicting the educational tracks that intellectually talented adolescents self selected (Humphreys et al.). Those with spatial ability as a relative strength compared to verbal ability were more likely to gravitate towards careers in mathematically related fields such as engineering and computer science while those with the inverse pattern tended to pursue careers in humanities, social science, medical arts, and legal fields (Humphreys et al.; Shea et al.).

People identified as having spatial gifts or talents are disproportionately undereducated and underemployed relative to their ability level when compared with equally gifted individuals with strengths in mathematical and verbal areas (Gohm et al., 1998). Individuals with high spatial abilities are more likely to drop out of school, are working in larger proportions in traditional blue-collar occupations, and hold a smaller proportion of credentials at every educational level beyond high school (Gohm et al.; Humphreys et al., 1993). Failure to identify and nurture the strengths in children with spatial gifts not only does a disservice to the children involved, but also to society (Shea et al., 2001). Spatial learners' strengths – the ability to grasp complex systems, the ease in which they discover relationships, and their high levels of creativity and originality - are prerequisites for contributions of new knowledge and unique problem solutions.

Shea et al's (2001) longitudinal study assessing spatial ability in students who scored at the top 0.5% in general intelligences at age 13 on the *SAT* demonstrated the importance of identifying children with spatial talents. They found that verbal and quantitative abilities alone, the most frequently assessed areas of intelligence, were insufficient descriptors of intellectually talented students.

> This investigation uncovered a huge range in spatial ability among intellectually gifted students identified by conventional talent-search procedures.…An issue of particular concern is the likelihood that some intellectually promising students are not being identified by current practices, because of the lack of attention given to spatial ability.…there are obviously large numbers of "high-space" (i.e., spatially talented) students who do not meet the minimum math or verbal criteria for participation in talent searches….selecting for the top 3% of verbal-mathematical ability will result in the loss of more than half of the students representing the top 1% of spatial ability! (Shea et al., 2001, p. 612)

The percentage of American students pursuing careers in fields which utilize spatial skills such as mathematics and engineering is far below the percentage of students pursuing careers in verbally based domains such as business and the humanities. Among undergraduates enrolled at universities and colleges in the United States who had declared a major during the 1999-2000 school year, only 5.6% indicated that they would prefer a career in engineering and a mere 0.8% were majoring in mathematics. Contrast this with 17.6% of the undergraduates working toward a career in the arts and humanities and 18.6% in business and management (National Science Foundation, 2004a).

At the graduate level, an increasing number of foreign students are entering United States universities to pursue degrees that require high spatial abilities. At U.S. institutes of higher learning in 2001, 24% of all doctorate degrees were earned by students from foreign countries. While foreign nationals earned approximately a quarter of the doctorates in the United States, they earned a much higher percentage of degrees in mathematics and engineering. A total of 43% of the mathematics doctorates and 51% of engineering doctorates conferred in the U.S. in 2001 were earned by students from foreign countries (National Science Foundation, 2004a). In 2003 U.S. doctoral degree recipients comprised a mere 37% of the doctorates conferred in engineering while foreign recipients earned 61% of the degrees (National Science Foundation, 2004b). Conversely, U.S. citizens account for 82% of doctorates earned in non-science and non-engineering fields, with nonresident aliens earning only 12% of the advanced degrees in these areas (see Figure 1). An increasingly technological world requires that American students obtain a solid background and encouragement in areas such as science, engineering, and mathematics to keep pace with other nations (Shea et at., 2001). The statistics suggest American students are not pursuing higher education in these critical disciplines.

Identifying children with spatial gifts at a young age can help them to develop their talents and use these talents to their fullest potential. The educational system has an obligation to encourage students with spatial strengths, not only for the benefit of the individual student, but also for the benefit of society. An understanding of children who possess both outstanding spatial abilities and weak sequential skills can enable educators to better understand how to teach these children in the classroom, perhaps ensuring that the next generation of Einsteins and daVincis will be more readily discovered.

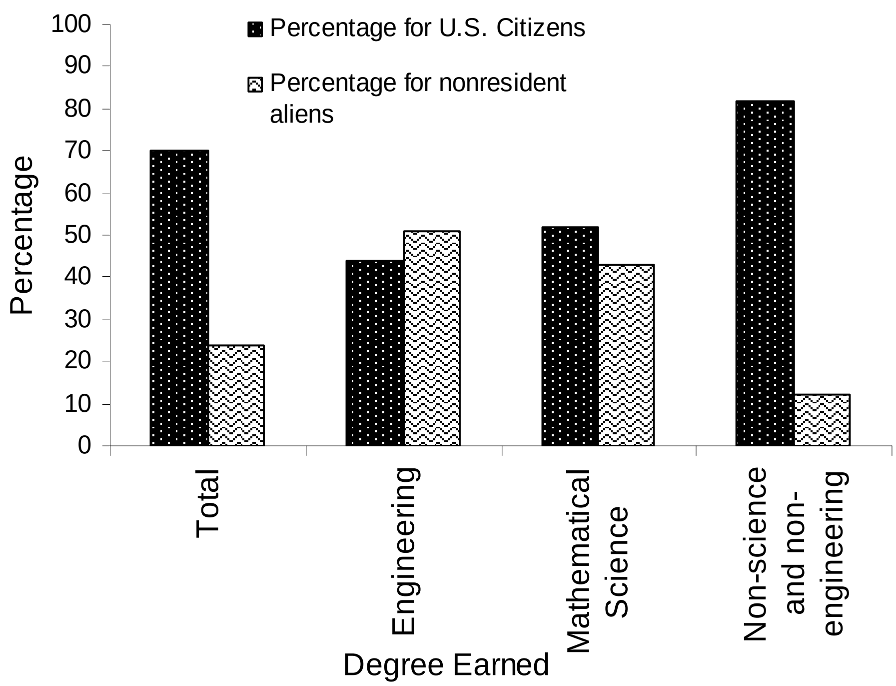

Figure 1. Comparison of Earned Doctoral Degrees for U.S. Citizens and Nonresidents Aliens in 2001.

Research Questions

To better help students with spatial strengths develop their gifts, teachers and parents must have access to an efficient and effective identification tool. An instrument, *My Thinking Style (MTS)* (Mann, 2004a), was developed for this study in an effort to provide such an identification tool. The purpose of this study, therefore, was to determine if a correlation exists between *MTS* a 14 statement self-report instrument and the *Naglieri Nonverbal Ability Test* (*NNAT*) (Naglieri, 1997), a standardized measure of nonverbal ability. In addition, the study investigated the relationship between the *MTS* survey and the score of the block design subtest from the *Wechsler Intelligence Scale for Children – Fourth Edition* (*WISC-IV*) (Wechsler, 2003). The relationship between the students' *NNAT* score and the results of the block design subtest were also examined. While primarily a quantitative study, a qualitative approach was used to evaluate the effectiveness of *My Thinking Style.* Designed as a self-report instrument, it was administered by the researcher in one-on-one interviews with students, thereby enabling the researcher to probe the reasoning of the students as they responded to each statement. The intent was to elicit information from the students regarding their interpretation of the statements on the survey to ascertain whether or not the researcher's intent when writing the statements aligned with student perceptions and interpretations. The following research questions served to guide the study:

1. Is there a statistically significant correlation between the scores on the *Naglieri Nonverbal Ability Test* and scores on *My Thinking Style*?
2. Is there a statistically significant relationship between the *Naglieri Nonverbal Ability Test* and block design scores on the *Wechsler Intelligence Scale for Children-Fourth Edition*?
3. Is there a statistically significant relationship between block design scores on the *Wechsler Intelligence Scale for Children-Fourth Edition* and scores on *My Thinking Style?*
4. Do specific patterns of responses exist in students who score more than two standard deviations above the norm on the block design subtest of the *Wechsler Intelligence Scale for Children-Fourth Edition?*
5. Do specific patterns of responses exist in students who score in the 95th percentile or higher on the *Naglieri Nonverbal Ability Test*?
6. Are there differences in the responses given by students who score in the bottom quartile and the top quartile on *My Thinking Style*?

Definition of Terms

My Thinking Style (Mann, 2004a) is a student self-rating scale of sequential/spatial learning style preference.

The *Naglieri Nonverbal Ability Test* (Naglieri, 1997) is a measure of nonverbal ability. Reasoning is assessed using figural designs intended to provide an estimate of general ability.

Block design is a subtest of the *Wechsler Intelligence Scale for Children – Fourth Edition* designed to measure the ability to analyze and synthesize abstract visual stimuli. The ability to separate figure and ground in visual stimuli, nonverbal concept formation, visual perception and organization, simultaneous processing, and visual-motor coordination are also involved in this subtest (Wechsler, 2003).

The variables being studied are self-report of sequential/spatial learning preference, nonverbal ability, and visual-spatial perceptual reasoning ability. Sequential/spatial learning preference refers to an individual's preferred mode of learning and processing information. Sequential learners have the ability to express themselves easily with words and use a verbal coding centered on a linguistic approach. Spatial learners prefer a visual approach and use an imagistic code to organize their thoughts. They have the ability to create and manipulate images mentally (Dixon, 1983; Gardner, 1993; Mann, 2001, 2005; Silverman, 2002; West, 1997). Nonverbal ability is the ability to interpret and organize visual material (Naglieri, 1997; Sattler, 2001). Visual-spatial perceptual reasoning ability refers to the ability to visually manipulate images in space by generating, retaining, retrieving, and transforming gestalten or whole patterns in a flexible and fluid manner (Dixon, 1983; Gardner; Lohman, 1993, 1996; Mann, 2005; Silverman, 2002; Wechsler, 2003; West, 1997).

In this chapter, a description of the problem and an overview of this study were presented. In Chapter Two, a review of literature related to spatial reasoning is provided. The methodology used in this study is explained in Chapter Three with the results of the research described in Chapter Four. Chapter Five includes a discussion of the implications of this research, implications for classroom teachers, the limitations of the study, and provides suggestions for further research.

CHAPTER TWO

REVIEW OF THE LITERATURE

The relevant research is discussed in this chapter, definitions of spatial ability are summarized, and the relationship between spatial reasoning and working memory is discussed. The next section includes a description of the characteristics of children who have strengths in spatial reasoning. In the final section of this chapter identification procedures used to locate children with spatial strengths are discussed as are the relative strengths and weaknesses of various methods of identification.

Definition of Spatial Ability

Researchers discuss two methods of representing knowledge, the verbal code and the imagistic code (Gardner, 1993). Verbal coding refers to linguistics, and individuals with talents and strengths in this area have the ability to express themselves easily with words as do authors, playwrights, and poets. The imagistic code refers to the ability to create and manipulate images in the mind. Kozhenvikov, Hegarty, and Mayer (2002) stated that there are two groups of visualizers, those of high spatial ability and those of low spatial ability. Visualizers with low spatial ability are adept at visual imagery and have the ability to represent the form, color, brightness, and other aspects of an object's appearance. These people are good at pictorial imagery and excel at constructing detailed and vivid mental images. High space visualizers are good at schematic imagery and excel at spatial imagery which refers to the representation of the spatial relationships between parts of an object and how those objects move or are represented in space. They can easily perform mental rotations on complex three-dimensional images. Of the two types of imagery abilities, individuals with strengths in schematic imagery, which is associated with spatial ability, tend to be more successful at mathematical problem solving than individuals with strengths in pictorial imagery (Hegarty & Kozhevnikov, 1999).

Among the factors identified through analysis of test scores in intelligence tests, are verbal ability and spatial ability (Johnson-Laird, 1985). Spatial ability involves the visual manipulation of objects (Gardner, 1993; Olson, 1984; West, 1997), the ability to comprehend the relationships between fluid, changing patterns (Dixon, 1983) and the ability to manipulate complex visual material (Shea et al., 2001). It refers to "competence in encoding, transforming, generating, and remembering internal representations of objects in space and their relationships to other objects and spatial positions" (Cooper & Regan, 1984, p. 138-139). Spatial ability is a dimension of cognition that combines with verbal and quantitative abilities to define how an individual perceives the world and acquires new knowledge (Gardner; Shea et al.). Individuals who possess spatial strengths are adept at using images to search for solutions to problems and express their thoughts, and spatial ability has been shown to be a better predictor of accuracy in reasoning than verbal ability. West (1997) described a hierarchy in spatial thinking skills in which each step is more complex than the one before (see Figure 2). West viewed the process of spatial thinking of which the highest levels were manifested in the creative work of persons such as in Picasso, Edison, Rodin, daVinci, and Einstein.

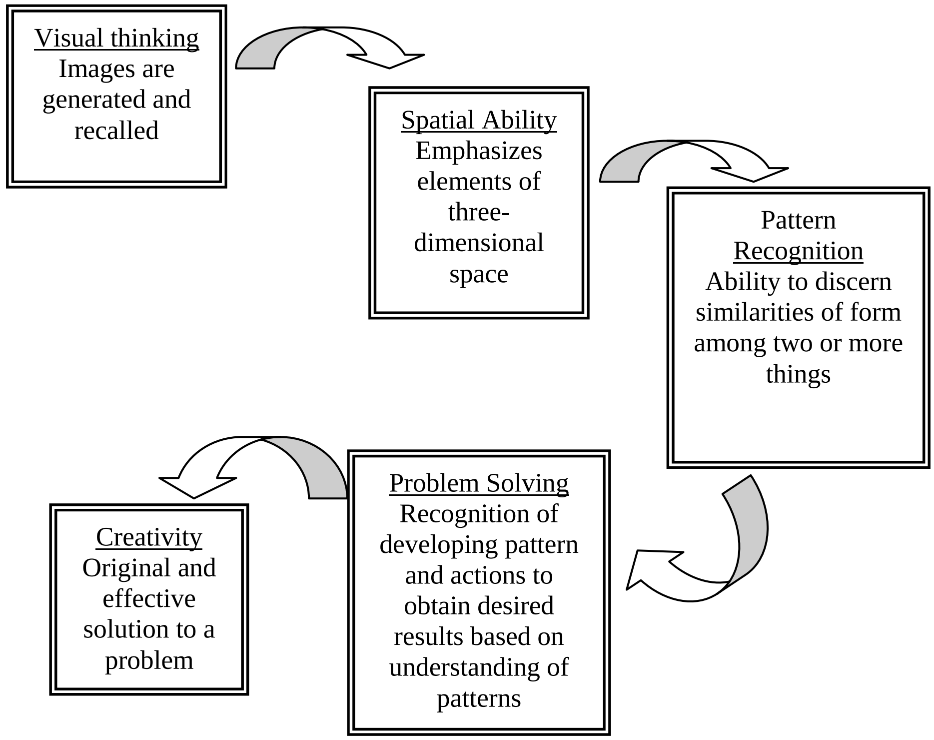

Figure 2. A visual interpretation of Thomas West's process of spatial thinking steps.

Extensive research has been conducted on the development of verbal skills and memory span in children, but by comparison, the spatial memory span has received only cursory attention (Chuah & Maybery, 1999). An examination of working memory, which involves the temporary storage and manipulation of information, is important in understanding the differences between spatial and verbal intelligence as working memory is necessary for a wide range of complex cognitive skills (Baddeley, 2003). "WM [working memory]…may be the crucial underpinning (or at least an important component) of the well-known psychometric concept of general intelligence" (Miyake, Friedman, Rettinger, Shah, & Hegarty, 2001, p. 622). Neuroimaging studies of the brain have shown that accessing the imagistic code and the verbal code are distinct processes. The three major components that comprise working memory are the phonological loop, which manages verbal material; the visuospatial sketchpad, responsible for processing visual-spatial material; and the central executive element that regulates the phonological loop and the visuospatial sketchpad. The central executive is responsible for attentional control and is a prinicipal factor in determining individual differences in working memory span (Baddeley).

Phonological working memory and visuospatial working memory are separate entities and involve different neurological channels. Visuospatial working memory is responsible for the maintenance and manipulation of spatial information (Kwon, Reiss, & Menon, 2000). Smith and Jonides (1997) used positron emission tomography (PET) to determine which areas of the brain are active when the different working memory systems are engaged. Their research found that when an individual was involved in solving a task using spatial memory, the four areas of the brain that were activated were located in the right hemisphere whereas, six of the seven areas activated while using verbal memory were in the left hemisphere with the seventh being a midline structure. More recent research confirms and expands on the asymmetry between the phonological (verbal) and visual-spatial domains (Miyake et al., 2001). Miyake et al. researched the roles of short-term memory

(STM), responsible for simple storage tasks, and working memory (WM), which is more complex and involves not only storage, but also processing of information. A partitioning of STM and WM was evident in the phonological loop with the two forms of memory being related but separable constructs. The nature of this separability is illuminated by the additional finding that the WM span tasks were able to predict performance on general fluid intelligence tests even after the common variance associated with the STM span tasks was partialed out, whereas the STM span tasks were no longer significantly related to general fluid intelligence after the common variance associated with the WM span tasks was partialed out (Miyake et al.).

This separation indicates that the central executive functioning is more involved in WM tasks and the WM span tasks are better predictors on cognitive tasks than STM span tasks. Spatial transformations place heavy demands on WM and consequently spatial tests often show high correlations with tests of general fluid ability (Lohman, 1996).

While the visuospatial domain has not been studied as extensively as the verbal domain, evidence suggests that the distinction between the STM and WM is not as pronounced in the visuospatial sketchpad as it is in the verbal domain (Miyake et al., 2001). The central executive is involved in both the simpler tasks used to test STM and the more complex tasks of the WM. This extensive executive involvement even for the simpler visuospatial STM span tasks is consistent with the proposal that the visuospatial sketchpad is closely tied to the central executive. It also supports the suggestion that the maintenance of even a single item may require central executive involvement (Miyake et al., 2001). Spatial reasoning is most often associated with inductive reasoning, but also may be involved in deductive reasoning tasks. Knauff, Mulack, Kassubek, Salih, and Greenlee (2002) investigated the use of spatial imagery during the performance of deductive reasoning tasks. Using functional magnetic resonance imaging (fMRI), they found evidence that deductive reasoning tasks are processed in the portions of the brain known to be neurologically related to spatial representations and processing. The strength of the association between the visuospatial sketchpad and the central executive indicates that assessment of spatial tasks may be more closely related to general intelligence than to tests of verbal skills.

Characteristics of Children with High Spatial Abilities

> We need to have special concern for children whose greatest strength is the grasp of complex structure. When these children have difficulty using conventions of detailed sequencing, their special knowledge tends not to be recognized by others, and they are frustrated in using their specialized giftedness. (Dixon, 1983, p. 116)

Spatial ability is closely related to visual thinking but is not a single entity; consequently, there is no one pattern of learning characteristics that will manifest itself in children with spatial gifts (Dixon, 1983; Olson, 1984). Combinations of the traits described vary widely from individual to individual. Puzzles, mazes, map reading, model building, tinkering, and craftwork are some of the activities in which children who manipulate images in their minds excel (Dixon; Mann, 2001, 2005; Olson; Silverman, 1989, 2002; West, 1997). Children with these skills are adept at dismantling mechanical devices and often discover a more efficient way to put them back together. Legos™, Construx™, K'nex™, Tinker Toys™, and Erector Sets™ are often favorite toys of spatial children as are the boxes in which they are packaged. Their creativity results in their use and manipulation of toys in new and unique ways. These students may display an inability to concentrate on verbal information and exhibit a poor sense of the passage of time, especially when they are involved in their area of passion or play with their favorite toys.

At school, students with spatial gifts struggle to master material requiring rote memorization, yet thrive when involved in situations requiring higher order thinking skills and creative problem solving (Baum, 1984; Mann, 2001; Silverman, 1989, 2002). A child with spatial strengths may have difficulty if asked to memorize the names and the dates of the battles of the Civil War, but may excel in understanding the causes of the war, the impact specific battles had on the outcome of the war, and how America's Civil War compares and contrasts to civil wars in other nations. A student with spatial talents may struggle with mathematical computation but be able to solve abstract mathematical problems with ease. The child may verbalize highly creative stories but be unable to transfer the story into the written word (Mann, 2001; Silverman, 1989, 2002). Reading aloud may not be a good indicator of a spatial learner's reasoning abilities as oral reading may be laborious, while silent reading may result in a high level of comprehension (Mann, 2001; Silverman, 2002).

Spatial learners tend to process information more slowly and their high level of internal mental activity may be interpreted as intentional off-task behavior or daydreaming (Dixon, 1983; Silverman, 2002; West, 1997). In reality, they may have to consider the entire concept and reflect on how individual pieces fit into the main scheme of information as they are holistic in their approach to learning (Silverman, 1989, 2002), and may have difficulty attending to details that are presented in isolation. They often display an ability to grasp complex relationships between systems, are aware of physical properties and patterns (Dixon) and understand how the pieces fit together. This holistic preference for acquiring knowledge may result in a weakness in planning sequentially.

Spatial learners often demonstrate a confusing mixture of strengths and weaknesses as suggested in Table 1. Language is a sequential process that may present the spatial learner with significant difficulties. The English language presents particular problems for these learners as it has little phonetic consistency, and the exceptions to the rules of English can turn the learning process into a memorization nightmare that can overwhelm a student who seeks patterns and connections (Dixon, 1983). Educators need to be aware of the language issues that can be problematic for students with spatial strengths and offer them counseling that moves them in the direction of careers that value their special abilities. Students with spatial strengths that are nurtured and encouraged often pursue careers that fit their unique abilities and enable them to excel in occupations in fields such as, architecture, engineering, mechanics, computer science, mathematics, and the physical sciences. These areas all require the abilities characteristic of individuals who possess spatial strengths (Baum, Dixon, & Owen, 1991; Dixon; Gardner, 1983; Shea et al. 2001; Silverman, 2002; West, 1997).

Table 1

Strengths and Weaknesses of Spatial Learners

Area of Strength	Perceived Weakness
Grasps relationships between systems	Has difficulty grasping isolated details
Excels with complex, higher level content	Struggles with easy or basic content
Is reflective	May be seen as a daydreamer
Has excellent memory for specific information	Has difficulty with rote memorization
Is preoccupied with ideas	Possesses weak social skills
Is able to manipulate visual images	Processes verbal communication slowly
Exhibits creative talent	Struggles in traditional academic settings
Excels at mathematical concepts	Has poor mathematical computation skills
Uses metaphoric language effectively	Rarely uses concise descriptions in language
Has strong reading comprehension skills	Has weak reading decoding skills
Is aware of physical properties and patterns	Is slow to process conventional understandings
Possesses a vivid imagination	Has difficulty putting stories into written form

(Dixon, 1983; Silverman, 1989, 2002; West, 1997)

Identification of Spatial Ability

> Central to spatial intelligence are the capacities to perceive the visual world accurately, to perform transformations and modifications upon one's initial perceptions, and to be able to re-create aspects of one's visual experience, even in the absence of relevant physical stimuli. (Gardner, 1983, p. 173)

Identification of spatially gifted children presents a unique set of challenges (Olenchak & Reis, 2002), as achievement tests commonly used as assessments in schools rarely include a nonverbal component or an assessment of spatial ability. Spatial ability is not easily expressed in verbal terms and demonstrated on pencil and paper tasks (Olson, 1984), and is therefore, difficult to evaluate on assessments administered on a large scale. The *Wechsler Intelligence Scale for Children (WISC)* can be a valuable tool for identifying children with spatial strengths. When using this assessment as a tool, it is advisable to carefully consider all subtest scores in addition to the Full Scale score or the Verbal and Performance Scores (Olenchak & Reis). The block design subtest has been found to be an accurate indicator of a child's spatial tendencies (Baum et al., 1991: Beckman, 1977, 1981; Dixon, 1983). Students who score more than two standard deviations above the norm on the block design subtest have been found to have spatial strengths (Beckman, 1977). In research conducted with students who scored 17 or more on the block design subtest of the *WISC*, Beckman found a high correlation between the subtest score and the profound intellectual thinking required of mathematics and science.

The nationally normed *WISC* provides a mean score for each subtest of 10 with a standard deviation of 3. Students with superior spatial ability often have scores over one standard deviation above the mean, or a score of 13 or better, on the block design subtest. Students with exceptional spatial skills and weak sequential skills often have approximately a two standard deviation range between the spatial subtests and the sequential subtests (Dixon, 1983). The discrepancies between scores on the *WISC* subtests are indicators that the child may have a strength in one area overshadowed by a weakness in another. The resulting lower Full Scale score on the *WISC* for students with spatial strengths and weak sequential skills cause them to be denied access to gifted services, and their strengths result in scores too high for identification for learning disability services.

The revised *Wechsler Intelligence Scale for Children*, now in the Fourth Edition, may improve the chances of identifying spatial students. In addition to providing a composite score representing a child's general intellectual ability, it also provides indices in Verbal Comprehension, Perceptual Reasoning, Working Memory, and Processing Speed. The Perceptual Reasoning Index (PRI) "is a measure of perceptual and fluid reasoning, spatial processing, and visual-motor integration" (Wechsler, 2003, p. 104). Block design is included in the subtests that comprise the PRI along with Matrix Reasoning, and Picture Concepts. This revision of the *WISC*, the *Wechsler Intelligence Scale for Children-Fourth Edition* has reduced the emphasis on time (Wechsler), which may benefit learners with spatial strengths. Silverman (2002) found that many spatial learners were overlooked on previous versions of the *WISC* due to the fact that certain subtests were timed. Because of their holistic approach to problem solving, spatial children tend to have slower processing speeds which result in a lower Full Scale score.

The Johns Hopkins University Center for Talented Youth has developed the *Spatial Test Battery* (Eliot & Stumpf, 1992) to assess visual-spatial ability. The purpose of the test is to provide an alternate means of determining eligibility for its programs for high ability students. The *SAT* and *PLUS Academic Abilities Assessment*, traditional assessments used for identification, have verbal and mathematical components. The *Spatial Test Battery (STB)* (Eliot & Stumpf) is intended to locate students who excel in mathematics, computers, graphic design, and science, who might be missed through the original identification process. The *STB* is administered through computer test centers and a fee is charged to each student taking the assessment. The test is intended for students in grades 5 through 12.

Silverman (2002) developed the *Visual Spatial Identifier,* a student self-rating scale designed to identify individuals as visual-spatial or auditory-sequential. The *Visual Spatial Identifier* uses a five point Likert scale self-rating instrument with 5 representing very true, 4 being true, 3 as mostly true, 2 as somewhat true, and 1 indicating not true. The instrument was validated with 447 fifth and sixth graders of whom 40% were Hispanic, 2% were “other minorities”, with the remainder being Caucasian. Students, parents, and teachers completed rating scales. Over half of the teacher questionnaires were eliminated from consideration because it was determined that participating teachers did not have a clear understanding of the study (Silverman, 2000) Teachers were then given a half day inservice and asked to identify a handful of students whom they perceived as high visual-spatial learners. Silverman reports a “notable 0.517 correlation” (p. 21) between teacher identification and the completed scale. The level of significance was not specified for this correlation. This means that there was a high correlation between the score on the *Visual Spatial Identifier* and the teachers' impressions of which students had spatial strengths after the teachers had been inserviced on the characteristics relating to the *Visual Spatial Identifier*. Silverman (2000) reported a reliability coefficient of .7046. This reliability coefficient was based on 554 cases consisting of a mix of student, parent, and teacher surveys. No reliability was stated for independent groups.

Mann (2004b) conducted a validation study with the *Visual Spatial Identifier* and administered the instrument to 145 third grade students participating in Project M^3: Mentoring Mathematical Minds, a national research and curriculum study. These students were drawn from eight different elementary schools in four different communities within Connecticut. A range of socio-economic status was represented and 32% of the sample was of minority status. The reliability coefficient for the 126 complete sets of data obtained was .459. Comparison of reliability results with the reported reliability for the instrument is not possible due to the fact that Silverman’s (2000) data consisted of a commingling of parent, teacher, and student reports and no reliability data for students alone was reported.

The *Visual Spatial Identifier* may eventually prove to be of value in identifying students with spatial strengths, but further research is necessary to determine its reliability and validity. Silverman (2002) stated, “We’ve established the validity of the *Identifier* for White and Hispanic males and females, ages 9-13, with 750 students in urban and rural geographic areas” (p. 332). Percentages of White and Hispanics or male and female students were not given and no descriptive statistics were specified relative to socio-economic status or urbanicity. The initial validation study claimed a reliability of .7046, however, that was based on a commingling of student forms, parent forms, teacher forms, and subjective teacher ratings taken after the teachers attended a half-day inservice on the visual-spatial concept. No reliability statistics were given for subsequent validation studies.

Gardner (1983) includes spatial intelligence as one of his original seven multiple intelligences. The validity of the multiple intelligences theory has been questioned due to a lack of empirical evidence (Lubinski & Benbow, 1995; National Research Council, 2002; Shearer, n.d.). The *Multiple Intelligences Developmental Assessment Scales (MIDAS)* (Shearer, 1996) is a self-rating scale developed to assess multiple intelligences and research has begun to determine its reliability. A study of teenagers, college and university students, and adults resulted in the spatial construct being split between two separate factors, one pertaining to spatial problem solving tasks and the other related to artistic design and creative projects. The reliability coefficient was .87 (Shearer, 1996).

In an effort to identify diverse populations of gifted learners, nonverbal assessments are growing in popularity. While nonverbal tests are not a new form of assessment, there has been an increase in the availability of these assessments since 1990 (National Research Council, 2002). One of the first widely used nonverbal assessments in the United States was developed to assess military recruits during World War I. The *Army Mental Test – Beta* form was developed to help identify soldiers with special talents or skills who had limited English proficiency (National Research Council). Assessments such as the *Army Beta* have been used by members of the business community and the military for over 50 years to identify adults with superior nonverbal reasoning skills. Nonverbal assessments are relatively new to mainstream educators, having been used in the past primarily by educators of deaf and hearing impaired students and developmentally delayed children with language deficits. Nonverbal tests differ in their reported psychometric properties (see Table 2) and there is disagreement in the field about what nonverbal assessments actually measure.

The performance scale from the *Wechsler Intelligence Scale for Children-Revised* has historically been used as a nonverbal test due to the reduced language demands of the subtests, Object Assembly, Block Design, and Picture Completion; however, the subtests require comprehension of lengthy and complex verbal instructions (National Research Council, 2002). It is not considered a nonverbal assessment by its developers.

Table 2

Psychometric Properties and Reliabilities for Three Nonverbal Ability Tests

Test Name	*Psychometric Properties*	*Split-half Reliability*
Naglieri Nonverbal Ability Test	Nonverbal measure of school ability Reasoning using figural designs	.86
Standard Progressive Matrices	Nonverbal test of reasoning ability Ability to form comparisons Ability to reason by analogy Ability to organize spatial perceptions	.90
Universal Nonverbal Intelligence Test	A nonverbal measure of general intelligence, cognitive abilities, and memory Ability to solve problems using memory and reason	.93

The *Naglieri Nonverbal Ability Test (NNAT)* purports to be a nonverbal measure of school ability (Naglieri, 1997). While the *NNAT* may be an accurate measure of nonverbal ability, Lohman (2003) asserts that it is unreasonable to consider it an accurate measure of school ability as it does not evaluate verbal or quantitative reasoning which are critical factors in school learning. Naglieri (2005) argues that research has shown that “using a general measure of ability that is not laden with verbal and quantitative knowledge is an appropriate way…to measure general ability” (p. 35). Naglieri defends the *NNAT* as a culture-fair measure of overall ability due to the fact that students are not required to read, write, or speak (Naglieri, 1997, 2005) while being assessed. It has been argued that despite decades of attempts, no one has been able to develop a "pure" measure of ability as to do so would require the elimination of all of the effects of education, culture, and ethnicity (Lohman, 2003, 2005). The *NNAT* has multiple formats and can either be administered individually or in a group setting.

The *Standard Progressive Matrices (SPM)* (Raven, Court, & Raven, 1998) is a test of nonverbal reasoning ability that provides a measure of intelligence based on figural reasoning (Sattler, 2001). The *SPM* is also purported to be culture-fair and relatively free of the influence of formal schooling, however it contains items that are more easily solved by individuals with training in geometric and algebraic reasoning (Cernovsky, 1997). The *SPM* appears to be a valid measure of nonverbal reasoning ability, but it needs to be normed on a representative sample of the U.S. population (Sattler). The *SPM* can be administered either in a group setting or individually.

The *Universal Nonverbal Intelligence Test (UNIT)* (Bracken & McCallum, 1998) is a general measure of intelligence and cognitive abilities (Fives & Flanagan, 2002). The directions for the *UNIT* are given through pantomimed gestures resulting in a test that has eliminated verbal instructions. Testing must be done on an individual basis and the directions can be difficult to follow for the administrator (Fives & Flanagan). The *UNIT* is an acceptable measure of nonverbal ability, but further research needs to be carried out to determine how it relates to other measures of intelligence (Sattler, 2001).

Nonverbal assessments should be considered measures of nonverbal ability. Identifying them as measures of general intelligence may be premature as further research into their reliability and validity is needed. Nonverbal assessments may have the potential to identify students with spatial strengths.

Not every child can take a *WISC* (Wechsler, 2003) or other assessment with a component designed to identify spatial strengths. The *WISC* and the *UNIT* (Bracken & McCallum, 1998) must be administered one-on-one by a licensed psychologist or other specially trained individual making it a time intensive endeavor and cost prohibitive for school districts. The *Naglieri Nonverbal Ability Test* and the *Standard Progressive Matrices* can be administered individually or in a group setting. The administration of either the *NNAT* or the *SPM* results in an expenditure of time and money for the school systems involved. To help educators locate students with spatial strengths it is necessary to develop more “user friendly” identification tools. A more practical approach in the process of identifying gifted spatial learners may involve a consideration of other indicators of spatial giftedness. Examination of students’ preferred methods of acquiring new knowledge and choice of activities, both in the classroom and at home, can help to identify children with spatial strengths.

This review of literature provides evidence for the importance of identifying students with spatial strengths and fostering those strengths. Research has shown that spatial reasoning is a viable construct and that further research is necessary to fully comprehend the need to integrate research and practice in the educational setting.

CHAPTER THREE

METHODS AND PROCEDURES

In Chapter Three, the methods and procedures used in this research study are discussed. The sample is described, the instruments, including two standardized tests and a survey, are explained, and the mixed methods procedures used to collect and analyze data are summarized.

Research Design

While primarily a quantitative study, this research used a mixed methods approach. Quantitative data were gathered using three instruments, the *Naglieri Nonverbal Ability Test (NNAT)* (Naglieri, 1997)*,* the block design subtest of the *Wechsler Intelligence Scale for Children-Fourth Edition (WISC)* (Wechsler, 2003)*,* and a learning style inventory, *My Thinking Style* (Mann, 2004a)*.* The self-report instrument, *My Thinking Style,* was administered during one-on-one interviews with the student participants. The answers to the statements were recorded by the researcher as were any additional comments the students made as they explained the reasoning behind their responses. Scores were obtained for the *NNAT*, which had been administered previously and the researcher administered the block design subtest from the *WISC.* A correlational design was used for this study to determine the degree of the relationship between scores on the self-report of sequential/spatial ability and scores on a measure of nonverbal ability, scores on the self-report of sequential/spatial ability and scores on a measure of visual-spatial perceptual reasoning ability, and scores on a measure of nonverbal ability and scores on a measure of visual-spatial perceptual reasoning ability.

Sample

The intent of the research was to find efficient and valid methods to identify students with spatial strengths at the elementary school level. The fourth grade level was of interest to the researcher because they were judged old enough to have some insight into the way they acquire and process new information. A convenience sample of 15 fourth grade students participated in the study. The students attended a PreK-4 elementary school in a northeastern state that was participating in the Project M^3: Mentoring Mathematical Minds Study, a national research and curriculum study. The school was located in a rural community near a major public university. The fourth grade consisted of two classroom teachers and the students who participated in the study were in these teachers' classrooms. Approximately 250 students attend the school and 15% are eligible for free lunch. During the 2003-2004 school year, 60% of the fourth graders met the state goal in mathematics, exceeding the state average by 3%. The fourth graders scored much better in comparison to the state in reading with 82.8% of the fourth graders meeting state expectations compared to the state average of 54.3%.

The mean age of the students was 9 years and 10 months. Ten of the students were boys and five were girls, and one student was African-American, three were Asian-American, and 11 were Caucasian (see Table 3). Minorities were represented in the sample by a larger percentage than the school at large with 27%

of the sample classified as minorities and 17.4% of the school population classified as minorities. During the 2003-2004 school year, 83% of the student body represented returning students from the previous year (Connecticut State Department of Education, n.d.). All of the study participants had attended this school in previous years. Two girls began attending the school in the middle of first grade, 12 of the 15 students had been there since the beginning of kindergarten, and one student had started school there as a preschooler.

Table 3

Ethnicity of Sample of Fourth Graders

	N	*Percentage*
African American	1	7%
Asian American	3	20%
Caucasian	11	73%

The students involved in the study were all performing on grade level or above in mathematics and reading. Participants in this study were students who had been evaluated for participation in Mentoring Mathematical Minds, a national curriculum and research study for high ability mathematics students. Through that study they had permission to participate in a wide range of assessments and while not all of the students were selected to participate in the study, every one had taken the assessments including the *Naglieri Nonverbal Ability Test*, (*NNAT*) (Naglieri, 1997). The *NNAT* had been administered in a group setting during the spring of

2003 by the students' classroom teachers when the students were in the second grade.

Table 4

Study Participant Pseudonyms, Ages, and Sex

Pseudonym	Age yrs:months	Sex
Steven	10:0	M
Polly	9:8	F
Cami	9:2	F
Lyndsey	9:6	F
Alan	9:11	M
Joel	10:1	M
Karl	9:2	M
Juan	10:1	M
Peter	9:11	M
Sierra	10:0	F
Andy	9:6	M
Eli	9:6	M
Caitlin	9:9	F
Bobby	9:11	M
Brent	10:4	M

University of Connecticut Institutional Review Board approval was secured to administer the self-report instrument, *My Thinking Style,* and the block design subtest of the *WISC-IV* to those students whose parents had signed informed consent forms specific to this study and to gain access to the students' *Naglieri Nonverbal Ability Test* scores. Every fourth grade student at the school who had previously taken the *Naglieri Nonverbal Ability Test* was invited to participate and the parents of 15 of the 41 students contacted gave permission for their children to participate in the study.

Instrumentation

The *Naglieri Nonverbal Ability Test* (Naglieri, 1997) was selected for this research study as it is being used by an increasing number of gifted and talented programs as an alternative to verbally-based assessment tools for identification of gifted children. *My Thinking Style* was designed with the intention of providing educators and parents with a simple tool to help identify children with spatial strengths. The block design subtest of the *Wechsler Intelligence Scale for Children-Fourth Edition* was chosen for this research study as it has been shown to be successful in identifying children with spatial strengths (Baum et al.,1991; Beckman, 1977; Dixon, 1983).

The *Naglieri Nonverbal Ability Test* (*NNAT*) (Naglieri, 1997) is a group-administered measure of nonverbal ability and problem solving designed to assess ability without requiring the student to read, speak, or write words or numbers. Students record their answers by circling their choice in the examination booklet.

The assessment has seven levels for students in kindergarten through twelfth grade. Out of five possible answers, students determine which one they feel best completes a figural matrix for each of 38 items. The items create four clusters: pattern completion, reasoning by analogy, serial reasoning, and spatial visualization. The *NNAT* was standardized in 1995 and 1996 with over 89,000 students from a wide variety of socioeconomic and ethnic groups, urbanicity, and geographic locations. An examination of internal consistency was performed using the Kuder-Richardson Formula #20, which revealed grade-based reliability coefficients from 0.83 to 0.93 and age-based reliabilities from 0.81 to 0.88. The Standard Error of Measurement ranges from 5.6 to 5.8 for the different levels.

My Thinking Style is a 14 statement self-rating scale (see Appendix A). The instrument is a forced-choice survey in which students are asked to select one of two preferences related to specific learning situations. “When I am thinking of new ideas, I like to: a.) Write down my new ideas or talk about them. b.) Daydream and make pictures of my ideas in my head” is a sample of the types of statements included in the survey (Mann, 2004a). Answers are scored on a 1 - 3 scale with 1 being associated with a preference for a sequential style of processing information, 2 being associated with answers that indicated the student did not have a preference for using one strategy over the other or that they used different strategies under different circumstances, and 3 being associated with answers aligned with preferences characteristic of individuals with spatial reasoning strengths. The instrument was designed using the visualizer-verbalizer dimension which fits the criterion of a learning preference (Mayer & Massa, 2003). Based on a review of literature, a pool of 15 statements was developed to measure learning preference aligned with the visualizer-verbalizer dimension. After development of the instrument, content experts were asked to evaluate each possible response on the instrument in terms of how well the statements fit the construct. Feedback received from the content experts led to revisions in the survey which involved the deletion of one statement and clarification of the wording on another. Content validity was established by a panel of 14 experts in the field of gifted and talented education and educational psychology. The percentage of agreement of the experts was calculated with 100% agreement on 13 of the 14 statements and 93% agreement on one statement.

Block design is a subtest on the *Wechsler Intelligence Scale for Children – Fourth Edition* (*WISC-IV*) (Wechsler, 2003) which measures the ability to analyze and synthesize abstract visual stimuli. The *WISC-IV* was standardized on a stratified random sample of 2,200 children. Internal consistency on the Perceptual Reasoning Index (PRI), of which the block design is a component, was established using the split-half method with a reliability coefficient of .92. The Standard Error of Measurement for this index ranges from 4.5 to 3.97. The subtests that comprise the PRI have reliabilities ranging from 0.82 to 0.89.

Research Methods

Students were interviewed prior to being tested on the block design subtest of the *Wechsler Intelligence Scale for Children-Fourth Edition.* The decision was made to hold the interview before asking students to complete the block design subtest for two specific reasons. There had been no prior contact between the researcher and the students in the study. Holding the interview session first enabled the researcher to establish a positive rapport with the students thereby increasing their comfort level when they were subsequently asked to solve the block design puzzles. The second consideration was test bias. The block design subtest is objective while the interview has the potential to be subjective. Students were asked to do the block design subtest after the interview so that the results of the subtest did not influence the researcher during the interview process.

The sequential/spatial self-report instrument, *My Thinking Style* (Mann, 2004a), was administered during this interview by the researcher. The researcher hand recorded the student responses to the statements and their rationale for their answers. After the interview, the researcher also hand scored the self-report scale. The length of each interview session was dependent on how quickly students completed the block design subtest and the elaboration of their replies to the survey statements with interview times ranging from 24 minutes to 65 minutes.

Students were introduced to the researcher by their classroom teacher and were told that the researcher would like to interview them about how children like to think. The interview started with the researcher asking informal questions about the activities that were on-going in the classroom, the weather, the student’s favorite toy or pets. The researcher then explained to the students that she was a former classroom and enrichment teacher and that she had gone back to school because she wanted to study more about how children learn. She told the students that they were part of a project she was doing for school. Students were told that they were going to be asked to answer questions that had no right or wrong answers. Students were then asked the 14 questions from *My Thinking Style* (Mann, 2004a) in the order in which they appeared on the survey (see Appendix A). If the child did not choose to elaborate, the researcher probed with questions such as, “Tell me more about that” and “Explain how you do that.”

Following the interview, students were administered the block design subtest from the *Wechsler Intelligence Scale for Children – Fourth Edition (WISC-IV)*. Proper administration protocol according to the *WISC-IV Manual* was followed by the researcher. During administration of the block design subtest, the researcher also recorded by hand any comments made or unique strategies used by the students as they proceeded to attempt to complete each design.

Upon completion of the interviews and classification of the student responses on the 1-3 scale, the researcher looked for patterns in student responses to the statements in *My Thinking Style* (Mann, 2004a). Problem solving strategies used when completing the block design subtest were also evaluated to determine if specific strategies were characteristic of students relative to their score. Characteristics of spatial learners were considered when examining the data and evaluating student responses. Student responses as they related to the intent of the statements on *My Thinking Style* were evaluated to determine the effectiveness of the instrument.

A quantitative analysis followed the interviews and administration of the block design subtest. Descriptive statistics were calculated for the *Naglieri Nonverbal Ability Test (NNAT),* the block design subtest of the *Wechsler Intelligence Scale for Children – Fourth Edition (WISC-IV)*, and *My Thinking Style (MTS)*. Correlations were analyzed to determine the relationship between the *NNAT* and the block design subtest, the *NNAT* and *MTS,* and *MTS* and the block design subtest.

Qualitative methodology was used in this study to evaluate perceptions of students reacting to spatial tasks and questions related to their preferred mode of learning. While the primary source of data collection in this research involved quantitative data, it was supported with qualitative data collected in the field in an effort to develop an understanding of the reasoning behind the student responses. Qualitative data may be used to clarify quantitatively derived findings (Strauss & Corbin, 1990).

The term qualitative research refers to any kind of research that results in findings not arrived at through statistical procedures (Strauss & Corbin, 1990) with the objective being the interpretion of how participants construct the world around them (Glesne & Peshkin, 1992). In this research, the problem under consideration, sequential vs. spatial learning style preference, had already been defined which led the researcher to conduct structured interviews with each student. A structured interview is focused with predetermined questions asked by the researcher (Lincoln & Guba, 1985). The researcher recorded the words and reactions of the participants as they completed the block design subtest of the *Wechsler Intelligence Scale for*

Children-Fourth Edition (Wechsler, 2003) and answered questions related to the statements on *My Thinking Style* (Mann, 2004a). This qualitative data were compared to the quantitative data under consideration: student scores on the block design subtest, *MTS,* and the *Naglieri Nonverbal Ability Test.* Using quantitative and qualitative data "as supplements, as mutual verification, and most important for use, as different forms of data on the same subject" (Glasser & Strauss, 1967, p. 18) in many instances is necessary to obtain evidence pertinent to specific research. The researcher used field study research to "explore the processes and meaning of events" (Marshall & Rossman, 1980). Quantitative data was supplemented with qualitative data to enable interpretation of student perceptions and reactions as they related to individual learning style preferences.

The quantitative and qualitative methodologies employed in this research study were described in this chapter. The data analysis and the results of the study are described in Chapter Four.

CHAPTER FOUR

DATA ANALYSIS

The analyses of the data collected in this research study are described in this chapter. The study consisted of three major components, the collection of scores on the *Naglieri Nonverbal Ability Test,* interviews with students using the statements from the *My Thinking Style* survey, and the administration of the block design subtest of the *Wechsler Intelligence Scale for Children*.

My Thinking Style

The interviews and probing questions based on the statements from *My Thinking Style* (Mann, 2004a) yielded some unanticipated results. The researcher read the 14 statements from *My Thinking Style* to each of the 15 students during separate interview sessions. A value of 1-3 was assigned for each statement and a 1 indicated a sequential reply, a 3 indicated a spatial reply, and a 2 indicated that the student did not have a preference for either answer.

Students were interviewed as they answered the questions about *My Thinking Style*, and some inconsistencies and discrepancies between the intent of each statement and the students' perceptions and interpretations of the statements were found. Three statements were determined to be problematic.

Statement 3:
When I want to remember something, I try to:
a. Repeat the words over and over in my head.
b. Make a picture of it in my head.

Three students stated that they would write what they needed to remember on paper, thereby making sure that they would remember it. One student commented that the strategy she used would depend on how difficult the concept was to remember. Another perceptive student explained, “It would depend on what was happening between the time I was given the information to remember and the time I was asked to remember it. I would repeat it over and over in my head, but if I had a lot of thinking to do in between, I would make a picture.”

An examination of the correlations between Statement 3 and the remainder of the statements on the survey indicated negative relationships ranging from $r = -.433$ to $r = -.152$, with 7 (statements 2, 4, 7, 8, 10, 11, and 12) of the 13 statements.

Statement 5:
When I am trying to solve a new kind of math problem I would rather:

a. Think up my own way to solve it.
b. Study a sample problem and solve mine the same way.

This statement was positively related with only Statement 3, $r = .650$. It was negatively related to every other statement with correlations ranging from $r = -.546$, $p < .05$ to $r = -.043$.

The majority of students said that they would think up their own way to solve the problem and then, if that didn’t work, look at a sample problem. The biggest obstacle was the students’ interpretations of “math problem”, which was different from the intent of the statement. The purpose of the statement was to have the students think about mathematics from a problem solving perspective in which the student was striving to come to a conceptual understanding of a mathematical concept. Examples given by the students were very procedural in nature, "If I didn't know how to solve 8 times 7, I would count by 8's until I had done it 7 times."

"I look for any possible things I see in it, like, is there multiplication in it, or division in it? And then, if I don't see anything, I study a sample."

Statement 9:
I am better at remembering:

a. What other people said.
b. What other people look like.

This statement was negatively related to five other statements (statements 1, 4, 5, 7, and 8) with negative correlations ranging from $r = -.568$, $p < .05$ to $r = -.043$. All of the students hesitated before answering the statement as if it were something they had never considered before. Two students replied, "Neither". Both of them then proceeded to discuss how they were very good at remembering things that interested them and very bad at remembering what they were supposed to remember. One girl explained, "It matters what they are saying. If someone is saying something that I really want to know, I'll remember what they said. Or, if they are saying something that really makes me mad, I'll remember what they said. If someone is wearing something really strange, I'll remember what they look like." Two other students responded, "I don't know." Using these analyses, and after a thorough examination of the correlations, and an evaluation of the student responses, a decision was made to drop statements 3, 5, and 9 from further analysis.

Table 5

Scores on the Naglieri Nonverbal Ability Test, My Thinking Style*, and* Block Design

Student	*NNAT* *Standard Age Score*	*MTS* *Raw Score*	BD *Standard Score*
Steven	137	11	8**
Polly	135	19	15
Cami	135	18	15
Lyndsey	132	31	16*
Alan	130	31	17*
Joel	120	19	7**
Karl	120	21	8**
Juan	120	24	13
Peter	118	26	18*
Sierra	113	29	10
Andy	113	28	16*
Eli	113	20	11
Caitlin	105	25	11
Bobby	99	18	12
Brent	95	17	9

* Identified as a member of the high visual-spatial group based on the block design subtest of the *Wechsler Intelligence Scale for Children-Fourth Edition*.
**Identified as a member of the low visual-spatial group based on the block design subtest of the *Wechsler Intelligence Scale for Children-Fourth Edition*.

The Cronbach alpha reliability for *My Thinking Style* with all 14 statements included was $r = .59$. After removal of the three questionable statements the reliability increased to $r = .759$. Interrater reliability was 98%.

Eleven of the original 14 statements on *My Thinking* Style were retained after analysis of correlations and student responses. The 11 statements on the self-report scale of sequential/spatial preferences were scored on a 1 to 3 scale. The maximum possible score on *My Thinking Style* was 33, while the minimum was 11. To obtain a score of 11 a student would have answered every statement indicating a preference for a sequential mode of thinking while a student who scored 33 would have indicated a preference for spatial reasoning while answering every statement. The minimum score earned in this research study was an 11 and the maximum was a 31 (see Table 5).

Naglieri Nonverbal Ability Test

Descriptive statistics were calculated for the *Naglieri Nonverbal Ability Test (NNAT)* (Naglieri, 1997) as indicated in Table 5. The *NNAT* scores were measured as standard age scores with a normed mean of 100 and a standard deviation of 15. For the participating students, the minimum score on the *NNAT* was 95 and the maximum score obtained was 137. The mean for the participants was nearly 19 points higher than the NNAT mean of 100 indicating that the sample participating in this study had a higher level of functioning on an assessment of nonverbal ability than the general population. The spread of scores was narrower than the population as the standard deviation was 2 points lower than the national norm of 15 reflecting the fact that these students were a more homogeneous group than the population at large as they were all at grade level or above in mathematics and reading.

Table 6

Means and Standard Deviations for Three Measures of Nonverbal Reasoning

	M	*SD*
NNAT	119	13.12
MTS	22.47	5.82
BD	12.4	3.60

Wechsler Intelligence Scale for Children – Fourth Edition – Block Design

The block design subtest of the *Wechsler Intelligence Scale for Children-Fourth Edition* is scored on a 1 to 19 scale with a standard deviation of 3. Validation studies of the WISC-IV have set the mean at 10. The minimum score for this research study was seven, one standard deviation below the mean, and the maximum was 18, almost three standard deviations above the mean. On average, the students in the study performed higher than the general population (*M* = 12.4, *SD* = 3.6) (see Table 5). Block design assesses spatial visualization and mental rotation through duplication of drawings in increasingly complex block arrangements with bi-colored cubes. The designs increase in difficulty starting with four blocks and progressing to nine block designs and children are expected to complete each puzzle within a specified amount of time.

Research Question 1

Is there a statistically significant correlation between the scores on the Naglieri Nonverbal Ability Test and scores on My Thinking Style?

The relationship between nonverbal ability as measured by scores on the *Naglieri Nonverbal Ability Test* (Naglieri, 1997) and sequential/spatial reasoning preference as measured by scores on *My Thinking Style* (Mann, 2004a) was investigated using Pearson product-moment correlation coefficient. There was not a statistically significant relationship between the two variables, r = -.007 (see Table 7).

Table 7

Intercorrelation for Scores on Three Measures of Nonverbal Reasoning

	NNAT	*MTS*	BD
NNAT	--	--	--
MTS	-.007	--	--
BD	.298	.580*	--

*p < .05.

Research Question 2

Is there a statistically significant relationship between block design scores on the Wechsler Intelligence Scale for Children-Fourth Edition and the Naglieri Nonverbal Ability Test?

The relationship between nonverbal ability as measured by scores on the *Naglieri Nonverbal Ability Test* (Naglieri, 1997) and visual-spatial perceptual ability as measured by scores on the block design of the *Wechsler Intelligence Scale for Children-Fourth Edition* (Wechsler, 2003) was investigated using Pearson product-moment correlation coefficient. There was not a statistically significant relationship between the two variables, r = 298 (see Table 7).

Research Question 3

Is there a statistically significant relationship between block design scores on the Wechsler Intelligence Scale for Children-Fourth Edition and scores on My Thinking Style?

The relationship between visual-spatial perceptual ability as measured by scores on the block design of the *Wechsler Intelligence Scale for Children-Fourth Edition* (Wechsler, 2003) and spatial thinking preference as measured by scores on *My Thinking Style* (Mann, 2004a) was investigated using Pearson product-moment correlation coefficient. There was a statistically significant relationship between the two variables, r = .580, p < .05 (see Table 7). The effect size of approximately .6 indicates that there was a strong relationship between the students' visual-spatial perceptual ability as measured by the block design subtest from the *WISC-IV* and their perceived spatial thinking preference as measured by *My Thinking Style*. Student performance on visual-spatial perceptual reasoning as measured by the block design subtest accounts for 34% of the variance in preferred learning style as measured by *My Thinking Style.* The results suggest that if children have high visual-spatial perceptual reasoning skills they will tend to obtain a high score on the *My Thinking Style* learning style inventory.

Research Question 4

> *Are there patterns of responses given by students who score more than two standard deviations above the norm on the block design subtest of the Wechsler Intelligence Scale for Children-Fourth Edition?*

Students who scored more than two standard deviations above the norm on the block design subtest of the *Wechsler Intelligence Scale for Children-Fourth Edition* (Wechsler, 2003) completed the puzzles quickly using a holistic approach. The normed mean for the block design subtest is 10 with a standard deviation of 3. Four students in this study, Alan, Lyndsey, Andy, and Peter obtained block design scores of 16 or greater which would place them in the category of students with high visual-spatial perceptual reasoning strengths (see Table 8). Alan, Lyndsey, and Andy also had scores in the top quartile on *My Thinking Style* (Mann, 2004a) while the fourth student, Peter, had a score that was in the top third of the participants. All four students in the high visual-spatial group solved the block design puzzles in less time than the remainder of the participants with a mean completion time for problem 6 of 11.25 seconds compared to the mean of the remainder of the students at 26.09 seconds. The results of puzzle 7 were similar as the top group of four students obtained a mean solving time of 11 seconds and the rest of the participants obtaining a mean of 25 seconds. Three students successfully completed all of the puzzles in the block design subtest and they were the students with the top three scores on *My Thinking Style,* Alan, Lyndsey, and Andy.

Table 8

Raw Scores of Students Identified as High in Visual-spatial Ability Based on the Block Design Subtest

	NNAT	*MTS*	BD
Alan	130	31	17
Lyndsey	132	31	16
Andy	113	28	16
Peter	118	26	18

Many students who scored below this top group would start to solve the problem, work toward a correct solution, and then give up and start from the beginning again. None of the four students in the high visual-spatial group, Alan, Lyndsey, Andy, or Peter, used similar tactics. All four students in the top quartile exhibited a confidence about solving the block design puzzles and focused intently on their solutions. They tended to look at the design in the book and then quickly manipulate the blocks to create a duplicate pattern as they appeared able to quickly visualize what needed to be changed to replicate the illustration in the book. If they made an error, they only attempted to rearrange the block that was representing the portion of the design that was incorrect. The students who scored in the bottom quartile on the block design, Joel, Steven, Brent, and Karl, used a deliberate approach to solving the puzzles. They often would place the blocks directly over the illustration in the book to see if they matched and if the placement of one block appeared incorrect to them, they frequently would dismantle the entire puzzle and start all over from the beginning again. This strategy of decomposing puzzles was often carried out multiple times during each attempt at a solution. Every block was configured the same with two red sides, two white sides and two sides that were divided diagonally into half red and half white. The students were shown the blocks at the beginning of the exercise and had agreed with the researcher that every one of the blocks looked identical, yet the students in the low spatial group would continually pick up and put down blocks as they searched for the "right one" to complete the design.

Other than their holistic approach to assembling the blocks to create a representation of the illustration in the test booklet, there was little consistency in the strategies used to solve the problem by these four students. Alan looked for what he considered the easiest starting point, "Ok, on this one (puzzle) the center one (block) is red so I'll start there." For a problem in which the design was rotated 45 degrees from previous problems he said, after examining it for a few seconds, "Oh! Now I get what the trick is."

Lyndsey worked her way through the puzzles quietly and quickly and confidently exclaimed, "There!" as she completed each one.

Andy was quick to see connections between puzzles. For one of the nine block puzzles he immediately recognized that one of the rows of blocks was identical to a row in the previous puzzle.

Peter explained, “I do puzzles a lot. It helps to do the outside first.” He solved each problem starting with the outside edge of the design.

Alan, Lyndsey, and Andy, all members of the high visual-spatial group, were anxious to know when they could make their own design out of the blocks, something that none of the other 12 students asked. Asked what their favorite toy was, 3 of the 4 in the high visual-spatial group, two of the boys and the girl, immediately said, “Legos”. Andy, dressed in his New England Patriots championship sweatshirt asked, “Does football count as a toy?” None of the students who scored below the top quartile on the block design subtest listed Legos™ or any other building toy as their favorite. Of the four students who obtained the lowest scores on the block design subtest, Steven chose books as his favorite toy, Joel stated that he didn’t know what his was, Brent shrugged his shoulders, and after some thought, Karl said, “Micro Matchbox cars, I guess.”

Research Question 5

Are there patterns of responses given by students whose score on the Naglieri Nonverbal Ability Test is in the 95th percentile or higher?

The 95th percentile on the *Naglieri Nonverbal Ability Test* is equivalent to a standard age score of 130 or higher. Reflecting the fact that there was not a statistically significant correlation between the *Naglieri Nonverbal Ability Test (NNAT)* (Naglieri, 1997), a measure of nonverbal ability, and the block design subtest, a measure of visual-spatial perceptual reasoning, there were no consistencies among the responses of students who scored in the 95th percentile or higher on the *NNAT*.

Table 9

Comparison of Scores on Three Instruments for Students with Scores Greater than the 95th Percentile on the Naglieri Nonverbal Ability Test

Student	*NNAT*	*MTS*	BD
	Standard Age Score	*Raw Score*	*Standard Score*
Steven	137	11	8
Polly	135	19	15
Cami	135	18	15
Lyndsey	132	31	16
Alan	130	31	17

Five of the 15 participating students, Steven, Polly, Cami, Alan, and Lyndsey, earned scores greater than the 95th percentile on the *Naglieri Nonverbal Ability Test* (Naglieri, 1997) obtaining scores of 137, 135, 135, 132, and 130 respectively indicating that they had high levels of nonverbal ability (see Table 9). Of the students in the high visual-spatial perceptual reasoning group, Alan, Lyndsey, Andy, and Peter, only two of them, Alan and Lyndsey were also members of the group of five students who represented the high nonverbal ability group. Andy and Peter, the other two students in the high visual-spatial perceptual reasoning group, scored at the 88^{th} and 81^{st} percentile respectively. Of the three students in the high nonverbal ability group who were not also members of the high visual-spatial perceptual reasoning group, Steven scored in the average range on visual-spatial perceptual reasoning as measured by the block design subtest and Polly and Cami obtained scores of 15 which were one standard deviation above the norm (see Table 9).

My Thinking Style (MTS) (Mann, 2004a) measures sequential/spatial learning preferences and Steven obtained the lowest possible score on the *MTS* indicating a strong preference for processing information using linear or sequential strategies. On the nonverbal assessment, the *Naglieri Nonverbal Ability Test* (Naglieri, 1997), Steven obtained the highest score of all of the students in the research study. Steven, and two other students in the high nonverbal ability group, Polly and Cami, had scores in the lower third of all participants on the *MTS* indicating that three of the five students in the high nonverbal ability group had a preference for sequential processing. The other two students in the high nonverbal ability group, Alan and Lyndsey, who were also members of the high visual-spatial perceptual reasoning group, scored in the top quartile on *MTS* suggesting a preference for using spatial strategies while learning.

While Alan and Lyndsey, who were in the high visual-spatial perceptual reasoning group, used holistic strategies during the problem solving session with block design, the other three students in the high nonverbal ability group, but not in the high visual-spatial group, Steven, Polly, and Cami, used very different strategies. All three of these students worked very carefully and deliberately on the puzzles. They carefully examined the illustration in the test booklet and compared individual blocks to the pattern in the booklet. They also tended to solve the problems working either from the bottom of the puzzle and progressing up or from the top of the puzzle and working their way down. This row by row construction differed from the way that Alan and Lyndsey tended to solve the puzzles which involved using a figure-ground comparison.

Research Question 6

Are there differences in the responses given by students who obtain scores on My Thinking Style in the bottom quartile and the top quartile?

Steven, Bobby, Brent, and Cami scored in the bottom quartile of the group of participants on *My Thinking Style,* indicating that they had a preference for reading directions before looking at illustrations, sounding out words in their head, “talking” about ideas in their head, being given verbal instructions, and being told how to do something rather than being shown (see Table 10). Their preferences may have indicated a verbal ideation in their thinking and a preference for learning in a sequential manner.

Table 10

Scores of Students in the Bottom Quartile of My Thinking Style

Student	*NNAT*	*MTS*	BD
	Standard Age Score	*Raw Score*	*Standard Score*
Steven	137	11	8
Cami	135	18	15
Bobby	99	18	12
Brent	95	17	9

Alan, Lyndsey, Sierra, and Andy were in the top quartile of *MTS* (see Table 11) and they expressed a preference for looking at illustrations before reading directions, writing a word and looking to see if it is spelled correctly rather than sounding it out, thinking about ideas in pictures, and being shown how to do something rather than being told how to do it. Their preferences indicate an imagistic and spatial ideation as they process information.

Table 11

Scores of Students in the Top Quartile of My Thinking Style

Student	*NNAT*	*MTS*	BD
	Standard Age Score	*Raw Score*	Standard Score
Alan	130	31	17
Lyndsey	132	31	16
Sierra	113	29	10
Andy	113	28	16

Three of the 4 students who expressed a preference for information to be presented verbally were not anxious to elaborate when it came to being interviewed. They answered the questions with succinct answers and seemed content not to dwell on the topic. The fourth student, Cami, was eager to give her input. She answered many of the questions with, “It depends.” When asked about the role she would prefer on a group project Cami stated, “If I were interested in the topic, I would want to write the report, but if I didn’t know much about it or didn’t care, I would rather make the charts and graphs.” Cami’s preference was to choose word games such as Scrabble™ over jigsaw puzzles, “If it were a good challenge. I don’t want to play it against someone easy.” She would rather read during her free time in class than build something if, “It were a good story.” Cami was focused on keeping herself challenged and interested in what she was doing and that became the determining factor in her responses.

Three of the four students who expressed a preference for information to be presented visually were quick to respond when being interviewed and did not elaborate. The fourth student, Alan, described thinking with the comment that his “brain is like a factory”. As he answered the questions, Alan often explained what he was “supposed” to do. When choosing between playing a word game such as Scrabble™ or doing a jigsaw puzzle he said, “Words are important for your education so I should pick that, but I would rather do a puzzle.” Asked if he would rather read or build something during free time Alan said, “It is important to read to get new ideas, you need that for your education. I like to read, but I would rather build something."

Student Interactions

The classroom environment in the two fourth grade classes in which these students were enrolled appeared supportive and positive. Both classroom teachers and the enrichment teacher, with whom most of these students interacted on a daily basis, created a climate that encouraged students with diverse learning styles and abilities. Students had opportunities to explore their areas of interest and were encouraged to use their strengths to help them acquire new knowledge. The classrooms were busy with a combination of small group activities and students working independently. Students transitioned in and out of the classroom on a regular basis to attend special classes in enrichment and special education. Each classroom had the daily schedule and assignments written on the board so students knew the academic expectations and could quickly check to see what they should be working on if they had just returned from a special class. Both classrooms had student teachers who were just beginning their training and often there was a teaching assistant present too. This created a student/teacher ratio that allowed many opportunities for individualized instruction. The teachers were extremely flexible and very willing to work with the researcher to release students for interviews and testing.

The behavior of the students in the high visual-spatial group varied within the classroom setting. Lyndsey, the girl in the group of high visual-spatial processors, appeared to have a very good relationship with her teacher. Her teacher was teasing her about being a princess and she immediately responded, “I’m not a princess, I’m the queen! Queen Elizabeth I…did you know she had black teeth, eewwww!” She proceeded to relate unusual facts about British royalty as she walked down the hall. While eager to talk to the researcher, she stayed on task not only during the interview and testing, but also during the class in which she was observed by the researcher.

Two of the three boys, Andy and Peter, were also cooperative and productive during class, although one of them seemed to get great pleasure in stealing his neighbor’s pencil box and name tag during the time the class was transitioning from one subject to another.

The student with the highest score on the sequential/spatial learning style inventory deserves special mention. During the parental approval process, Alan’s mother called the researcher to tell her, “I’m so glad you are doing this research. I’m surrounded by visual-spatial learners and I feel like we are speaking a different language most of the time!” Her son had the highest score (X=31) on the survey intended to identify students with spatial strengths and the second highest score (X=17) on the block design subtest. Alan scored two standard deviations above the mean on the nonverbal ability assessment, the *Naglieri Nonverbal Ability Test* (Naglieri, 1997). His score of 31 on the learning style inventory was the result of answering all but one statement in the affirmative for imagistic and spatial reasoning. He scored more than 2 standard deviations above the norm on the block design subtest. Alan was also the student who showed the greatest interest in explaining the workings of his mind. In the short amount of time the researcher interacted with this young man, it was evident that he fit many of the characteristics listed in Table 1. He was a self-professed daydreamer and this was apparent in the classroom as his teacher gently nudged him to focus on the task at hand. His perceptive descriptions about the workings of his brain, “My brain is a factory” and “My mind is a machine” indicated that he was appeared to be preoccupied with ideas and had spent time reflecting on topics that other 4th graders may rarely consider. Memory was a concern for him as he talked at length about his “memory slot” in his brain and how the things that he was supposed to remember (rote memorization?) got buried in the bin in his brain. He made extensive use of metaphoric language during conversation yet struggled to carry on a casual dialogue. Alan preceded each story with, “Can I tell you something?” Alan was confident in his problem solving capabilities as indicated by his comment as he worked to solve the final puzzle in the block design subtest, “Why didn’t they put a box (an outline) around it? Well, I’m a hard one to stump!”

When Alan was observed transitioning between classes there were four instances within a short period of time in which his teacher asked him to observe those around him in an effort to help him focus on the required task and he appeared to be lost in thought rather than focused on following directions. During an interview session with the researcher, Alan initiated a discussion about how his mind works,

> Can I tell you something? My mind is a machine. My brain is like a factory. I have memory slots in my brain. When I need to remember something, it gets dumped in a bin and goes to the memory slot where it gets buried in the back of my brain. Stuff gets scanned into my brain…like movies. Bad dreams get scanned in and get in the way of stuff I want to think about. Do you know what is in the way right now? Ghostbusters! I saw it over Christmas vacation and now it keeps getting in the way of stuff I'm supposed to remember.…Sometimes when I'm trying to remember what I'm supposed to be remembering, my brain shuts off and my brain floats aimlessly.

Alan went on to explain his use of imagery in his thinking,

> Can I tell you something? I make pictures in my head, but words are a part of the picture. First I picture the thing, like the water cycle, then words appear in the picture like labels for all of the different parts. Right now I have a picture of a truck in my head. It is a truck as big as a house that folds up into a smaller vehicle. It uses hydraulics to make the sides fold up over the top of the bed of the truck.

His description of the workings of his truck as he transformed it in his mind from a massive vehicle too big for the road, into something that could maneuver the local rural roads in his neighborhood continued for another 3 minutes. Another topic of conversation revolved around Alan's desire to build,

> Can I tell you something? As soon as I get my hands on a piece of paper, I draw on it or make a paper airplane. I stink at drawing humans or animals, but I love to draw things and designs. I am a destructor…I take things apart and then build and rebuild them. I would use a drill. I'm a hands dirty, down and dirty inventor. I love to make paper airplane, momentum planes.

His monologue on paper airplanes continued for another 3 to 4 minutes.

In this chapter, the results of the data analysis were displayed. In Chapter Five the implications of the results, implications for classroom teachers, limitations inherent in the study, and suggestions for areas of further research will be discussed.

CHAPTER FIVE

DISCUSSION AND IMPLICATIONS

This chapter begins with a discussion of the implications of this research study based on the results for the six research questions. Implications for the classroom are then discussed followed by limitations of the study. Suggestions for further research in the area related to this research conclude this chapter.

Implications

A variety of instruments were considered for this research and The *Spatial Test Battery (STB)* (Eliot & Stumpf, 1992), the *Visual Spatial Identifier (VSI)* (Silverman, 2002), and the *Multiple Intelligences Developmental Assessment Scales (MIDAS)* (Shearer, 1996) were deemed inappropriate. The *STB* was developed for students attending the 5th through 12th grades and this research is designed for 3rd and 4th grade students. The *VSI* has questionable reliability and needs further refinement. The *MIDAS* that has been researched on a large scale was intended for use with adolescents and adults and contains questions inappropriate for elementary students, such as “Do you parallel park a car on the first try?” (Shearer, n.d.)

Three nonverbal assessments were considered for this research, the *Universal Nonverbal Intelligence Test (UNIT)* (Bracken & McCallum, 1998), the *Standard Progressive Matrices (SPM)* (Raven, 1938) and the *Naglieri Nonverbal Abilities Test (NNAT)* (Naglieri, 1997). The *UNIT* has the highest reliability of the three assessments, r=.93, however, it must be administered on an individual basis. The intent of this research was to find an efficient method of identification; therefore, the *UNIT* was eliminated from consideration. The *SPM* and the *NNAT* have been suggested as tools for use in the identification of gifted children (Lewis, 2001; Matthews, 1988; Mills & Tissot, 1995; Naglieri & Ford, 2003). The decision was made to use the *NNAT* as the researcher had received an increasing number of requests from school districts about the appropriateness of using the *NNAT* as an identification tool for their gifted and talented programs. The *NNAT* had also been used as one instrument in the identification process for an elementary mathematics research study and the scores and students were readily available to the researcher.

Research has shown that intelligence is comprised of three components: verbal ability, nonverbal reasoning ability, and spatial ability (Mervis, Robinson, & Pani, 1999). In a recent study of precocious youth, two distinct forms of giftedness were analyzed, verbal and nonverbal. Verbally precocious students scored higher on verbal and general knowledge tests while mathematically precocious students scored higher on tests of nonverbal reasoning, spatial ability, and memory. A factor analysis of the student test scores revealed three factors: verbal, nonverbal, and spatial (Benbow & Minor, 1990). The distinction between nonverbal reasoning ability and spatial ability is supported by the results of this research study in which a statistically significant relationship was not found between the *Naglieri Nonverbal Ability Test (NNAT),* a measure of nonverbal reasoning ability, and the block design subtest of the *Wechsler Intelligence Scale for Children – Fourth Edition,* a measure of spatial reasoning ability. In addition, there was not a statistically significant relationship between the *NNAT* and *My Thinking Style,* a self-report measure of learning style that distinguishes between sequential and spatial learning preferences. Based on the results of this research, it would be inappropriate to use the *Naglieri Nonverbal Ability Test* as tool in the identification of elementary children with spatial strengths.

Performance on a measure of nonverbal ability, the *Naglieri Nonverbal Ability Test,* was not related to visual-spatial ability as measured by the block design subtest of the *Wechsler Intelligence Scale for Children-Fourth Edition.* Joel, who had the lowest score on the block design subtest, scored one standard deviation below the mean (*X*=7) while he obtained a score in the 91st percentile on the *NNAT*, a score that was over two standard deviations above the mean. Steven obtained the highest possible score on the *NNAT,* a score in the 99th percentile which is over 3 standard deviations above the mean, yet his score on the block design subtest was an 8 which is almost a full standard deviation below the mean of a 10. The three students who had scores in the 99th percentile on the *NNAT,* Polly, Cami, and Steven, all used a very deliberate problem solving approach while completing the block design puzzles, unlike the students who obtained high scores on the block design, a measure of visual-spatial reasoning. The results of the *Naglieri Nonverbal Ability Test (NNAT)* (Naglieri, 1997) did not predict student performance in visual-spatial perceptual reasoning as measured by the block design subtest of the *Wechsler Intelligence Scale for Children-Fourth Edition* (Wechsler, 2003). These results support the research of Kozhenvikov, Hegarty, and Mayer (2002) who found that there are two types of visualizers, high spatial and low spatial. The students who did exceptionally well on the block design subtest of the *WISC-IV* may be representative of the high spatial ability visualizers who are characterized as being good at schematic imagery. The students who obtained high scores on the *NNAT* and low scores on the block design subtest may be adept at visual imagery, excelling at constructing detailed and vivid mental images, but may struggle to comprehend spatial relationships between parts of an object and how they are represented in space.

The block design subtest is a powerful test of visualization requiring an understanding of spatial relationships of objects or configurations (Mervis et al., 1999). Individuals of different profiles and ability levels tend to solve problems on spatial tests such as the block design in different ways (Lohman, 1996). The students in this research study demonstrated this distinction. The students who scored two standard deviations above the norm on the block design, Alan, Lyndsey, Andy, and Peter, used a holistic approach to solving the problems and there was little trial and error in their work as they assessed the situation and changed one or two blocks to perfect the design.   The students who obtained scores in the bottom quartile of the block design subtest, Joel, Steven, Brent, and Karl, were very deliberate in the approach to solving the problem examining each block individually, placing it over the illustration in the test booklet and frequently dismantling their design if something did not look right to them.

The high visual-spatial group solved the problems more quickly than the low visual-spatial group. The mean solving time for the high visual-spatial group was 11 seconds for problem number 7, while it took the low visual-spatial group an average of 39 seconds. None of the students in the low visual-spatial group was able to complete any of the 9 block designs in the allotted time. If an individual takes a long time to solve a spatial problem, success in solving the problem may be more indicative of patience or persistence than of spatial visualization skill (Smith, 2001).

It is not the ability to remember stimuli, but the ability to remember systematically structured stimuli that distinguishes between individuals high in spatial ability and individuals low in spatial ability (Lohman, 1996). At some point during the administration of the block design subtest, each of the students who were low in spatial ability, Joel, Steven, Brent, and Karl, dismantled the puzzle and started over again. The students in the group high in spatial ability, Alan, Lyndsey, Andy, and Peter, never completely dismantled a puzzle, choosing instead to change only the block that was incorrectly placed. This “holistic inspection” or global visual-spatial processing may be the basis of many real-world pursuits related to mechanical skill, carpentry, invention, visual artistry, surgery, and interpreting X-rays or magnetic resonance images (MRI) (von Karolyi & Winner, 2004; von Karolyi, Winner, Gray, & Sherman, 2003). It has even been suggested that visual-spatial ability is so strongly related to competency and the quality of results in complex surgery that it could potentially be used in resident selection, career counseling, and training of future surgeons (Wanzel, Hamstra, Anastakis, Matsumoto, & Cusimano, 2002).

There was a statistically significant relationship between the block design subtest of the *Wechsler Intelligence Scale for Children – Fourth Edition* and *My*

Thinking Style, $r = .580$, $p < .05$, with a strong effect size. Performance on the block design subtest accounted for 34% of the variance in learning style preference as indicated on *My Thinking Style.* "In some cases, a simple self-rating of spatial ability or of learning style can be an effective substitute for longer, more time-consuming instruments" (Mayer & Massa, 2003, p. 839). This appears to be the case with *My Thinking Style* and the block design subtest of the *Wechsler Intelligence Scale for Children-Fourth Edition.*

The ability of the students who were members of the high visual-spatial perceptual reasoning group to visualize the solution to the problem relates to the answers they gave on *My Thinking Style* indicating they had a preference for picturing ideas in their heads, doing jigsaw puzzles, and engaging in construction activities. Students in the low visual-spatial group indicated a preference to "talk" about ideas in their head, play word games such as Scrabble™, and read or write rather than build. Students with spatial strengths are known to have a preference for Legos™ and other building toys (Mann, 2001, 2005; Silverman, 2002) and that was the favorite toy of the majority of the high visual-spatial group. In the low spatial group there was no consensus as to their favorite toy, however, none of the group members included any type of building toy among their favorites.

Alan exhibited many characteristics of children with spatial strengths and his conversational style was typical of students with spatial strengths and sequential weaknesses (Silverman, 2002). He frequently interrupted the flow of conversation with the question, "Can I ask you something?" Each time he asked the question, the conversation was at a point where he could have easily transitioned to his next thought without requesting permission. The question may have been asked to allow him time to gather the words that he was searching for into his head. The block design results indicated he could easily manipulate visual images and was aware of physical properties and patterns and this was reinforced by his detailed description of the transforming hydraulic truck that was described earlier. Yet verbally he struggled with the precision of his words, rarely using concise descriptions as each story describing his thoughts lasted for several minutes.

Identifying students with spatial strengths such as Alan has major implications, especially when considering the shortage of mathematicians, physical scientists, and engineers in the United States. Spatial abilities have been found to be an important factor in higher-order thinking in science and mathematics (Lohman, 1996). Extensive research has shown a relationship between spatial ability and mathematical problem solving performance (Hegarty & Kozhevnikov, 1999; Lohman, 1996; Solano & Presmeg, 1995). Beckman (1981) found a direct relationship between the ability of adolescents to deal with inquiry based learning situations in mathematics and science and their *WISC* block design subtest scores. Students who scored 13 or less showed little ability in investigations involving inquiry despite the fact that a score of 13 is one standard deviation above the mean. Ability increased as scores rose with children who scored 17 or higher showing outstanding ability. The results of this research indicate that educators and parents may be able to quickly and easily locate students with spatial strengths using the *My Thinking*

Style instrument and these are the children who could become the next generation of gifted mathematicians, physical scientists, and engineers.

Implications for the Classroom

To be successful in school, students with a visual-spatial approach to learning need to have their strengths recognized and nurtured. The students in this research study were in classrooms with teachers who appeared to encourage creative thinking and acknowledge student strengths. A supportive classroom environment is essential for children with spatial strengths (Silverman, 2002). *My Thinking Style* has the potential to assist educators with the identification of children with these strengths. Identification of students with spatial strengths is a critical step in the development of an appropriate educational program for these children. Identification must be followed by the implementation of effective strategies for students who have a holistic and inductive approach to learning. "For these people, it is sometimes far easier to learn firsthand from nature than it is to learn secondhand from books," (West, 1997, p. 12). Increasing the level of difficulty, encouraging visualization, teaching holistically, using humor, color, mnemonics, and using manipulatives are methods that may be successfully used with these learners (Mann, 2001; Silverman, 2002).

The most important thing that educators need to realize is that it is essential for them to encourage the child's strengths and not dwell on the weaknesses. Gifted learners with spatial strengths may exhibit their greatest abilities outside of the classroom. Educators must learn how to nurture these students' strengths which include creativity, ingenuity, and adaptability, as these are areas that are often highly valued by society and are essential tools for effective and creative solutions to real life problems.

Limitations

There are several limitations to consider when interpreting the results of the study. The results can only be generalized to the 4th grade students from Connecticut who participated in this study. The voluntary nature of the sample and the small sample size limits generalizability.

The results of the sequential/spatial learning preference self-rating scale, *My Thinking Style* (Mann, 2004a), the nonverbal ability measure, *Naglieri Nonverbal Ability Test* (Naglieri, 1997) and the visual-spatial perceptual reasoning assessment, the block design subtest of the *Wechsler Intelligence Scale for Children-Fourth Edition* (Wechsler, 2003), are dependent upon the individual student's attitudes and motivation at the point in time during which the student is completing the scale or taking the test.

The block design subtest of the *Wechsler Intelligence Scale for Children – Fourth Edition* was administered after the interview in an effort to reduce researcher bias. The researcher was responsible for conducting the interviews and assigning scores to student responses which may lead to researcher bias.

Interpretation of the results has limits as correlations break down complex relationships into simpler forms. It is possible that a significant correlation or a non-significant correlation was the result of relationships other than the ones being studied in this research. The relationships discussed in this study can not be assumed to be causal.

Suggestions for Further Research

The identification and education of gifted spatial learners is an area in which a scarcity of research exists. A variety of identification procedures used to locate these children should be analyzed in an effort to determine which systems are feasible and accurate. To confirm its validity, further research using *My Thinking Style* should be carried out with children at all age levels in school as well as with adults. It should also be validated with a diverse population of children who will provide the opportunity to look at cultural trends and the impact of socio-economic status. Educators may discover many more gifted children in underserved populations by looking at spatial strengths. Hilberg and Tharp (2002) found that American Indian adolescents performed better on subtests linked with visual-spatial processing than their non-American Indian counterparts.

The field of gifted education would benefit from longitudinal studies of gifted children with spatial strengths to determine what factors contribute to their successes and frustrations. An analysis of successful adult problem solvers and creative producers could help to determine whether they have a preference for verbal reasoning or whether they view the world through an imagistic code. If it becomes evident that these adults have a preference for imagistic reasoning and have spatial strengths, educators must ask if they are selecting all of the talented children who can benefit from gifted programs at the elementary and secondary school level.

The field of special education in the area of specific learning disabilities would benefit from analysis of student strengths in the area of spatial reasoning. Interventions designed around teaching strategies that are purported to be effective with learners with spatial strengths could be implemented in an effort to help students compensate for weak sequential skills in an effort to determine if these strategies are more effective than currently used compensation techniques.

There are specific teaching strategies that have been suggested to be effective in teaching students with spatial strengths and sequential weaknesses. Included are discovery learning, interdisciplinary approaches, teaching for conceptual understanding rather than recall of facts, use of guided imagery, use of eye-accessing cues, and use of visual instructional tools (Mann, 2001, 2005; Silverman, 2002). The effectiveness of these specific strategies should be evaluated using an experimental research design.

School performance and spatial reasoning ability should also be examined as high spatial ability has been linked to success in mathematical and scientific problem solving (Beckman, 1981; Hegarty & Kozhevnikov, 1999; Lohman, 1996; Solano & Presmeg, 1995). Statistics indicate that few of these children are following their areas of strengths, pursuing theses subjects in higher education settings, and choosing careers in the physical sciences, mathematics, or engineering (Gohm et al., 1998; Young & Bae, 1997). Tracking school achievement in gifted spatial learners to determine if there is a pattern of achievement and/or underachievement would give researchers and educators a better understanding of how to intervene to support these children.

Society needs the talents of gifted children with spatial strengths at the highest levels of the professional world (Dixon, 1983; Gohm et al., 1998, Silverman, 2002; West, 1997). It is essential that future research examine ways that they can best support visual-spatial children and their families in their educational and social-emotional growth. Without intervention, children with spatial strengths many not realize their full potential due to the predominately sequential school environments in the United States. This unique population may be at risk for underachievement and underemployment which could exacerbate the already critical shortage of talented individuals in fields such as engineering, mathematics, and the physical science. This research has shown that identification of children with spatial strengths can be carried out quickly and easily using an 11 statement survey. Early identification of spatial children can lead to early interventions designed to encourage their strengths and fully develop their areas of interest, strategies which have the potential to reduce the underachievement and underemployment of this valuable segment of our society.

> Perhaps the greater use of spatial tests, coupled with a much broader understanding of the importance of rediscovered spatial abilities, might help prevent conventional educational systems from dropping by the wayside those who are especially well suited to visual and spatial tasks – whether in creating grand illusions on film or in understanding visual patterns in the stock market or complex weather systems. (West, 1998, p. 5)

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Appendix A

My Thinking Style

This is to help you understand how you learn best. Some of these statements will describe you and some will not. Put a check after the words that best describe you. Make sure you answer every question and only mark put one check mark for each question. Thank you!

I am in the _______ grade. Check one:_______ I am a boy.______ I am a girl.

Sample.) If I had to choose I would most like to play with:	
Stuffed animals. ____	Real animals. ___X__

Just check ONE of the two answers!

1.) When I learn new information I try to:	
Make pictures of the idea in my head. ______	"Talk" about the idea in my head. _____

2.) During free time in class I would rather:	
Read, talk, or write. ______________	Build something with my hands. _____

3.) When I want to remember something, I try to:	
Repeat the words over and over in my head.__________	Make a picture of it in my head. __________

4.) If I were putting a model together I would rather:	
Look at the pictures but not read the directions. _______	Read the directions before I looked at the pictures. _____

5.) When I am trying to solve a new kind of math problem I would rather:	
Think up my own way of solving it._______	Study a sample problem and solve mine the same way._____

6.) At home when I have free time I would rather:	
Play with my toys. _________	Take my toys apart to see how they work._________

7.) When I learn something new, I would rather have someone:	
Tell me how to do it first. ________	Show me how to do it first. ________

8.) When I am trying to spell a hard word I:	
Write in on paper to see if it looks right. _____	Sound it out in my head. ________

9.) I am better at remembering:	
What other people said. ________	What other people look like. _______

10.) When someone says a word to me, I usually:	
Hear the word in my head. ______________	See a picture of the word or the thing in my head._________

11.) When my teacher gives me an assignment, I would rather he or she:	
Write the assignment on the board. ________	Tell me what the assignment is. ________

12.) If I were working on a group project, I would rather:	
Write the report. _________	Make the pictures, charts, and graphs. ______

13.) When I am thinking of new ideas, I like to:	
Write down my new ideas or talk about them. __________	Daydream and make pictures of my ideas in my head. ____

14.) If I could choose, I would rather:	
Play word games such as Scrabble, Boggle, and Password. _________	Put together jigsaw puzzles and other kinds of puzzles. _________

Appendix B

From: "Dr. Linda Silverman" <lindafay@rms.org>
Sent: Wednesday, March 17, 2004 3:16 pm
To: rebecca.mann@uconn.edu
Cc: gifted@gifteddevelopment.com , 'Allie Golon' <alexgolon@comcast.net> , 'Steven Haas' <haas@idcomm.com>
Bcc:
Subject: Identifier

Hi Becky.

Yes, your message did get buried at the bottom of nearly 800 e-mails and a desk that is in such disarray it's embarrassing.

Of course I remember you! Yes, of course you have our permission to use the Identifier in your dissertation, but the version you are referring to is outdated. The correct version can be downloaded from our website. It is now called the Visual-Spatial Identifier. It contains 15 items that have been validated with 750 students from 4th through 6th grade. We've just been offered a group of 63 third graders a couple hours from Denver, and we will probably validate the Identifier this Spring with that group. We are looking for a group of 7th graders to validate it with. We are also looking for specific ethnic groups to validate it with. We have developed a specific process for validation that works magnificently.

So, if you are planning to use the current Identifier with 4th through 6th Caucasian and Hispanic students in your dissertation (we have a Spanish version), we would be delighted. Please share your findings with us and post them on our Visual-Spatial Resource website. We would also love to have you post your GCT article to our VSR website and any other materials you would like. The website is undergoing major reconstruction, so it may be a few months before it's truly operational. Would you be interested at some point in monitoring a VSL discussion group on the website? Please contact Allie Golon about the VSR website, as she will be its webmaster. She's copied above.

If you have specific questions about the Identifier, please contact Steve Haas, the Project Director. He has all the stats on validity and reliability that you will need for your dissertation committee. I've copied Steve on this e-mail so you'll have his address.

Good luck and keep me posted.

Fondly,
Linda :)