Performance, Motivation and Gender with Two Different Instructional Approaches in Geometry

Erdogan Halat
PERFORMANCE, MOTIVATION AND GENDER WITH TWO DIFFERENT INSTRUCTIONAL APPROACHES IN GEOMETRY

By

ERDOGAN HALAT

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The members of the Committee approved the dissertation of Erdogan Halat, defended on September 8th, 2003.

Elizabeth Jakubowski
Professor Directing Dissertation

Steve Blumsack
Outside Committee Member

Kenneth Shaw
Committee Member

Leslie Aspinwall
Committee Member

Approved:

David F. Foulk, Chairperson, Department of Middle & Secondary School

The Office of Graduate Studies has verified and approved the above named committee members
This study is dedicated to my wife, Saliha, for her unforgettable support and patience, and to my daughter, Rana, for her love and big smiles.

This study is also dedicated to my parents and all family members for their best wishes.
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ABSTRACT

The purpose of this quantitative study was to compare performance and motivation of sixth-grade students engaged in instruction using a van Hiele theory based curriculum with sixth-grade students engaged in instruction not using a van Hiele theory based curriculum. While the instruction following the van Hiele theory used the curricula, CMP’s Shapes and Designs and Key Curriculum’s Discovering Geometry: An Inductive Approach, the comparative group’s instruction used Scott Foresman’s Middle School Math Course I. Two hundred seventy-three sixth-grade mathematics students – 123 in the control group, and 150 in the treatment group – were involved in the study.

The researcher employed a geometry test, Van Hiele Geometry Test (VHGT), used to measure students’ geometry performance and a questionnaire, Course Interest Survey (CIS), used to measure students’ motivation toward the geometry instruction. The VHGT and CIS were both administered to the students by the researcher before and after a five-week period of instruction during a single class period.

The paired samples t-test, the independent samples t-test, and ANCOVA with $\alpha = .05$ were employed in the analysis of the data. The study indicated that there was no statistically significant difference with respect to
students’ performance between the treatment and control groups, and that there was a statistically significant difference in regard to students’ motivation between the two groups favoring the treatment group instructed with the van Hiele theory based curricula. However, no statistical difference was indicated by gender in regard to students’ performance and motivation.
CHAPTER 1

STATEMENT OF THE PROBLEM

Orientation to the Problem

Results of the Third International Mathematics and Science Study (TIMSS) in both 1995 and 1999 clearly exemplify a general decline in academic performance between fourth and eighth graders. Both TIMSS studies reveal that the US fourth graders’ achievements in mathematics were at the top level among students from 42 countries that participated in the study. However, US eighth-grade students did not show the same success as fourth-grade students. Their mathematics’ performances were at the average level. Yet it is clear from the studies that there is a decline in the performance of these students in mathematics between fourth and eighth grade. What causes students’ low performances in mathematics at the middle school level? The reasons might be socio-economical, political, environmental, instructional, or other factors.

Over the past few decades, researchers have found that many students encounter difficulties and show poor performance in learning geometry in both middle schools and high schools (e.g., Van Hieles, 1957, 1986; Hoffer, 1981; Usiskin, 1982; Burger & Shaughnessy, 1986; Crowley, 1987; Fuys, Geddes, & Tischler, 1988; Gutierrez, Jaime, & Fortuny, 1991; Mason, 1997). Usiskin’s study (1982)
indicates that many students fail to grasp key concepts in geometry, and leave geometry class without learning basic terminology. He says that systematic geometry instruction might help students gain greater geometry knowledge and proof writing success.

Burger & Shaughnessy (1986) claim that sequencing instruction has positive effects on students’ success and feelings about self, the topic, and skills. If initial activities are frustrating and not interesting, students might not be motivated to learn what the teacher is trying to teach them. At the same time, if the activities are too easy, they might not attract students’ attention to the topic and might fail to generate a sense of success. The tasks in instruction should contain respectable challenges that students can achieve and, when they do, precipitate a sense of pride (Hoffer, 1986; Messick & Reynolds, 1992).

Moreover, research shows a decline in students’ motivation toward mathematics courses (e.g., Gottfried, Fleming, & Gottfried, 2001). Furthermore, according to Billstein & Williamson (2003), “declines in positive attitudes toward mathematics are common among students in the middle school years” (p.281). In fact, Ryan & Pintrich (1997) and Dev (1998) state that there is a positive correlation between students’ performance and motivation in mathematics.

According to Usiskin (1982), Burger & Shaughnessy (1986), Fuys et al. (1988), Messick & Reynolds (1992) and Geddes & Fortunato (1993), Reys, Reys, Lapan, Holliday, & Wasman (2003), and Billstein & Williamson (2003), the quality of instruction strongly influenced by curricula is one of the greatest influences on students’ performance in mathematics classes. No one type of instruction can
respond to the needs of all students who may be varied in their interests, talents, and learning styles. Nor can one type of instruction be employed 100 percent of the time. This is why the other approaches, such as student-centered, cooperative learning, discovery learning and so forth are recommended for the teachers to enhance the effectiveness of their teaching and the students’ learning. These approaches also should not be utilized 100 percent of the time (Skemp, 1987; Dunn, 1990; Messick & Reynolds, 1992).

Fuys, Geddes, & Tischler (1988) also promote the idea that no one type of instruction can support the needs of students to reach a higher level of reasoning. According to them:

It is possible that certain methods of teaching do not permit the attainment of the higher levels so that students cannot gain the methods of thought at these levels. It is also possible to face some phenomena that would take place between a student and a teacher who are operating at different levels and also between a student and a textbook author (p.76).

For Dunn (1990), each child has an inherent curiosity and love of learning; and each child has a unique intelligence, level of capability, and learning style. Messick & Reynolds (1992) support Dunn’s belief about the middle school students in their descriptions of middle school students:

The middle level student has lively curiosity and shows enthusiasm in active learning environments. Student behavior is highly egocentric but often moderated when interacting with classmates or other peers. This student has a broad range of interests and is eager to pursue them. Students are eager to develop skills, but their attention span for doing so may be short. The middle school students are increasingly interested in understanding the meaning and perplexities of life, and is concerned about issues and is learning to discuss them. The intellectual, philosophical, biological, sociological, moral or ethical nature of topics all has increasing appeal (p.38-39).
Therefore, these positive factors should be utilized for instructional purposes.

As expressed above, it is apparent that the students in any given classes may show variation in interests, capabilities, and intelligences. All of these translate into corresponding variations in learning styles, or preferred modes of learning. Gardner’s theory of multiple intelligences and Jung’s personality types may be examples for different learning styles or preferred modes of learning (Messick & Reynolds, 1992). In responding to this variation, the instructors show different ways for students to succeed based on their learning styles. Furthermore, it is also very important and necessary to give students experience in adapting to other types of learning. These studies suggested that different instructional approaches should be utilized in teaching, and students should be given a degree of freedom to choose activities that enhance their understanding of the subject.

The role of instruction is prominent in teaching and learning geometry as expressed by Usiskin (1982), Fuys, Geddes, & Tischler (1988), and Messick & Reynolds (1992). Moreover, the curriculum materials strongly influence teachers and guide instructions in the mathematics classes (e.g., Driscoll, 1980). No one type of instructional approach can meet the needs of students who are varied in interests, talents, and learning styles to increase their understanding in mathematics. In addition, none of them can be employed 100 percent of the time because the topic and circumstances vary. It is clear that these approaches help students enhance their knowledge and develop their skills.
However, the more systematically structured instruction, the more helpful it will be for the middle school students to overcome their difficulties and to increase their understanding of geometry. Furthermore, the National Council of Teachers of Mathematics (NCTM) (1989) recommends the use of learning theories for guiding instructional practices.

Research on geometry learning (e.g., Fuys, Geddes, & Tischler, 1988) has utilized a model for teaching and learning posited by Pierre and Dina van Hiele in the late 1950s. The van Hieles described five levels of reasoning in geometry. These levels are level-I (Visualization), level-II (Analysis), level-III (Ordering), level-IV (Deduction), and level-V (rigor) (Van Hiele, 1986). Descriptions of these levels are below.

**Level-I: Visualization or Recognition.** At this level students recognize and identify geometric figures according to their appearance, but they do not understand the properties or rules of figures. For example, they can identify a rectangle, and they can recognize it very easily because of its shape, which looks like the shape of a window or the shape of a door.

**Level-II: Analysis.** At this level students analyze figures in terms of their components and relationships among components and perceive properties or rules of a class of shapes empirically, but properties or rules are perceived as isolated and unrelated. A student should recognize and name properties of geometric figures.

**Level-III: Ordering.** At this level students logically order and interrelate previously discovered properties and rules
by giving informal arguments. Logical implications and class inclusions are understood and recognized.

**Level-IV: Deduction.** At this level students analyze relationships of systems between figures. They can prove theorems deductively, construct proofs, and they can understand the role of axioms and definitions. A student should be able to supply reasons for steps in a proof.

**Level-V: Rigor.** At this level students are able to analyze various deductive systems like establishing theorems in different axiomatic systems, and they can compare these systems. A student should be able to know, understand and give information about any kind of geometric figures.

In addition to the levels, the following characteristics have been established:

1. Each van Hiele level has its own linguistic characters and its own system of relations based on these characters (Fuys et al., 1988).

2. Language structure is one of the key factors in the movement from the concrete level (level-I: Visualization/Recognition) to the abstract levels (level-V: Rigor) (Fuys et al., 1988).

3. The progress of a learner from one level to the next is more dependent on instruction than on student’s age or biological maturation (Fuys et al., 1988).

4. Different types of instructional experiences are important for progress (Fuys et al., 1988).

Briefly, the role of instruction is crucial in teaching and learning geometry as expressed by Usiskin (1982), Fuys, Geddes, & Tischler (1988), and Messick & Reynolds (1992). No one type of instructional approach can
meet the needs of students who are varied in interests, talents, and learning styles to increase their understanding in mathematics. In addition, none of them can be employed 100 percent of the time because the topic and circumstances vary. It is clear that these approaches help students enhance their knowledge and develop their skills. However, the more systematically structured instruction, the more helpful it will be for middle school students to overcome their difficulties and to increase their understanding of geometry.

**Purpose of the Study**

The study focused on a comparison of students’ performances and motivation in geometry at the middle school level. This focus was based on concerns expressed by Crowley (1987) as “the need now is for classroom teachers and researchers to refine the phases of learning, develop van Hiele based materials, and implement those materials and philosophies in the classroom setting” (p.15). The aim of this quantitative study was to compare performance and motivation of sixth grade students engaged in instruction using a van Hiele theory based curriculum with sixth grade students engaged in instruction not with a curriculum based on the van Hiele theory. The instruction following the van Hiele theory used the curricula, *Shapes and Designs* and *Discovering Geometry An Inductive Approach*. The comparative group’s instruction used the curricula, *Middle School Math Course I*. The researcher used the following questions and hypotheses to guide the study.
Research Questions

1- What differences exist between students who are instructed with a van Hiele theory based curriculum and students not instructed with a van Hiele theory based curriculum with reference to their performance in learning geometry?

2- What differences exist with respect to motivation between students instructed with a van Hiele theory based curriculum and students not instructed with a van Hiele theory based curriculum in geometry?

3- What differences exist in terms of performance in geometry between male and female students instructed with a van Hiele theory based curriculum?

4- What differences exist with regard to motivation between male and female students instructed with a van Hiele theory based curriculum in geometry?

Null hypotheses

$H_0$-1: There is no difference with reference to performance in geometry between students instructed with a van Hiele theory based curriculum and students not instructed with a van Hiele theory based curriculum.

$H_0$-2: There is no difference in respect to motivation in geometry between students instructed with a van Hiele theory based curriculum and students not instructed with a van Hiele theory based curriculum.

$H_0$-3: There is no gender difference as to performance in geometry between male and female students instructed with a van Hiele theory based curriculum.

$H_0$-4: There is no gender difference with regard to
motivation in geometry between male and female students instructed with a van Hiele theory based curriculum.

Alternate Research Hypotheses

$H_{a1}$: Students instructed with a van Hiele theory based curriculum perform better than students not instructed with a van Hiele theory based curriculum in learning geometry.

$H_{a2}$: Students instructed with a van Hiele theory based curriculum show stronger motivational performance than students not instructed with a van Hiele theory based curriculum in learning geometry.

$H_{a3}$: The mean score of male students with respect to performance is higher than that of female students instructed with a van Hiele theory based curriculum.

$H_{a4}$: The mean score of male students as to motivation is higher than that of female students instructed with a van Hiele theory based curriculum.

Significance of the Study

The researcher agrees with the recommendation of NCTM (1989) stating that new educational theories and approaches should be used in teaching in order to help students overcome their difficulties in mathematics. In addition, knowing theoretical principles gives teachers an opportunity to devise practices that have a greater possibility of succeeding (e.g., Swafford, Jones, & Thornton, 1997). Furthermore, standards-based curricula have positive impacts on students’ performance and
motivation in mathematics (e.g., Billstein & Williamson, 2003; Chapell, 2003). Based on over twenty years of research it is clear that the van Hiele theory is a well-structured and well-known theory having its own instructional phases in geometry. Many researchers have studied and confirmed different aspects of the theory since proposed by the van Hieles.

This study would add to the set of studies by examining the validity of the van Hiele theory in terms of curricula. According to Hoffer (1986), Mayberry (1983) and Fuys et al. (1988), two individuals (teacher and student, or student and textbook author) who reason with different linguistic symbols and use different relationships find communication very difficult. Therefore, if textbook authors write books based on the van Hiele levels it may be helpful for students in their learning because each van Hiele level has its own symbols and properties. In other words, using van Hiele levels means systematically sequencing materials and activities. Furthermore, it is possible that a van Hiele-based materials would help teachers understand student deficiencies and devise their practices based on the levels at which their students function (e.g., Crowley, 1987; Swafford, Jones, & Thornton, 1997).

The Van Hiele Theory

The National Council of Teachers of Mathematics (1989) suggests that new ideas, research findings and approaches be utilized in teaching and learning mathematics. Knowing theoretical principles provides an opportunity to devise practices that have a greater possibility of succeeding.
The van Hiele model of thinking that was structured and developed by Pierre van Hiele and Dina van Hiele-Geldof between 1957 and 1986 focuses on geometry. Today, this model is a foundation for curriculums implemented in mathematics classrooms in many countries, such as Netherlands, Germany, Russia and United States. Research since the early 1980s has helped to confirm the validity of the theory (e.g., Hoffer, 1981; Usiskin, 1982; Mayberry, 1983; Fuys, Geddes, & Tischler, 1988).

Since the mid 1980s there has been a growing interest in the area of teaching and learning geometry (e.g., Mayberry, 1981; Burger & Shaughnessy, 1986; Usiskin, 1987; Gutierrez, Jaime, & Fortuny, 1991; Clements & Battista, 1992; Burger & Culpepper, 1993; Mason, 1997). Educators agree with developing new ideas and strategies, and encouraging teachers and students to practice them in teaching and learning so as to overcome the difficulties encountered in the mathematics classrooms (e.g., Fuys, Geddes, & Tischler, 1984/1988; Crowley, 1987).

There is much research done on some specific part of this teaching and learning model. Wirszup (1976) reported first research about the van Hiele theory, which attracted educators’ attention at that time in US. In 1981, Hoffer worked on the description of the levels. Usiskin (1982) affirmed the validity of the existence of first four levels in geometry at the high school level. In 1986, Burger and Shaughnessy focused on the characteristics of the van Hiele levels of development in geometry. Their main objective was to investigate three questions. The first one was regarding whether the van Hiele levels are useful in describing students’ thinking processes on geometry tasks.
The second one was to determine if the levels could be characterized operationally by students’ behaviors. The third one was about designing an interview procedure that could reveal predominant levels of reasoning on specific geometry tasks.

Fuys, Geddes, and Tischler (1988) examined the effects of instruction on a student’s predominant Van Hiele level. Some of these well-known researchers, such as Usiskin (1982), Mayberry (1983), and Burger & Shaughnessy (1986) confirmed the validity of levels and investigated students’ behavior on tasks. Some of them, such as Usiskin (1982), Senk (1989), Gutierrez, Jaime, & Fortuny (1991), Mason (1997), and Gutierrez & Jaime (1998) evaluated and assessed the geometric ability of students as a function of van Hiele levels.

Components of the theory have been presented and described elsewhere (Usiskin, 1982; Mayberry, 1983; Burger & Shaughnessy, 1986; Fuys, Geddes, & Tischler, 1988). Different numbering scheme was used for the levels, 0 through 4 or 1 through 5 in different research studies. In this study, the 1 through 5 schemes was used for the levels. This scheme allows the researcher to use level-0 for students who do not function at what the van Hieles named the ground or basic level. It is also consistent with Pierre van Hiele’s numbering of the levels. All references and all results from research studies using the 0 through 4 scale have been changed to the 1 through 5 scheme.

Although the existence of level-0 is the subject of some controversy (e.g., Usiskin, 1982; Burger & Shaughnessy, 1986), Van Hiele (1986) does not talk and acknowledge the existence of such a level. However,
Clements and Battista (1990) talked about the existence of a level-0 called prerecognition. Clements and Battista (1990) have described and defined level-0 (Prerecognition) as “Children initially perceive geometric shapes, but attend to only a subset of a shape’s visual characteristic. They are unable to identify many common shapes” (p.354). For example, learners may see the difference between triangles and quadrilaterals by focusing on the number of sides the polygons have but not be able to distinguish between any of the quadrilaterals (Mason, 1997).

Usiskin (1982) described the characteristics of the van Hiele levels with their names as:

“1. Fixed Sequence: A person cannot be at level n without having gone through level n-1.
2. Adjacency: At each level of thought, what was intrinsic in the preceding level becomes extrinsic in the current level.
3. Distinction: Each level has its own network of relationships connecting those symbols.
4. Separation: Two persons who reason at different levels cannot understand each other.
5. Attainment: The learning process that leads to complete understanding at the next higher level has five phases: inquiry, directed orientation, explication, free orientation, and integration” (p. 77-78)

Phases of Instruction

The van Hieles (e.g., Mayberry, 1983; Hoffer, 1986; van Hiele, 1986) proposed that movement from one level to the next level includes five phases: information, bound (guided) orientation, explicitation, free orientation, and integration.

Phase 1: Inquiry or Information

The teacher sets an environment in which the conversation takes place between the teacher and the students about the topic to be studied. During this phase,
questions are asked and observations are made by the teacher and students about the objects of the study, which helps the teacher to evaluate students’ responses and to determine students’ prior knowledge about the topic. Van Hiele (1986) expressed that the student is also getting familiar with the context of the field of study involved.

Phase 2: Directed Orientation

It is time for the teacher to show carefully sequenced one-step tasks or activities to students to explore the topic. The learners begin to realize what direction the study is taking and van Hiele (1986) said that they become familiar with “principal connection of the network of relations to be formed” (p.177). In other words, the students are becoming familiar with the structures of the topic such as the figures, vocabulary, symbols, definitions, properties and relations. During this phase, the teacher organizes the one-step activities for specific responses or actions that are expected to come from the students, and the students generally follow the teacher’s instruction step by step.

Phase 3: Expliciting

Now, the students have gained insights in working with the structures of the topic. Therefore, it is time for the learners to verbally describe what they have observed or at least to express their ideas about the tasks and the structures of the topic. In addition, during this phase, the teacher has an opportunity to understand what perceptions the students have about the context of the field and to help students improve their knowledge towards the aim of the lesson. According to van Hiele (1986), during this phase the students learn to speak technical
language. The students are supposed to make their observations explicitly and begin to use accurate and appropriate vocabulary with the help of the teacher.

**Phase 4: Free orientation**

Now, the students are somewhat getting experienced with the domain. Therefore, they are ready for the multi-step tasks that can be solved in a variety of ways (as opposed to the one-step tasks of phase 2). It can be said that this is the further development of second phase (directed orientation) in which the student “learns to find his way in the network of relations with the help of the connections he has at his disposal” (van Hiele, 1986, p.177). In addition, because the students have experience in solving problems, they can perceive the most important relations in the context of the topic and figure out how to apply these relations.

**Phase 5: Integration**

According to van Hiele (1986), teaching process comes to an end with this final stage indicating that the students have reached a new level of thought and have increased their thought level in the new subject. At this stage the students are expected to form an overview of the subjects for themselves. They are supposed to summarize and reflect on the study of the topic that they have been exposed. “They are able to see the larger picture. The objects and the relations are unified and internalized into a new domain of thought” (Hoffer, 1986, p. 244). The teacher provides summaries of some of the main points of the subject that are already known by the students to help this process.
Definitions

Reeve (1996) defined the motivation as “the study of the internal processes that give behavior its energy and direction. Energy means that behavior is relatively strong, intense, and persistent; direction means that behavior aims itself toward achieving a particular purpose or goal.” (p.2).

There are two types of motivations defined for academic settings, intrinsic and extrinsic motivation (e.g., Csikszentmihalyi & Nakamura, 1984; Reeve, 1996). Middleton & Spanias (1999) described intrinsic motivation as “the drive or desire of the student to engage in learning ‘for its own sake.’ Students who are intrinsically motivated engage in academic tasks because they enjoy them. They feel that learning is important with respect to their self-images, and they seek out learning activities for the sheer joy of learning” (p.66). These students’ motivations tend to center on learning goals, such as understanding mathematical concepts and reaching mastery levels of what they are doing (e.g., Ames & Archer, 1988; Csikszentmihalyi & Nakamura, 1984; Reeve, 1996). In short, Gottfried, Fleming, & Gottfried (2001) defined it as “Intrinsic motivation concerns the performance of activities for their own sake, in which pleasure is inherent in the activity itself.” (p. 3).

Extrinsic motivation: Students who are extrinsically motivated are getting involved in educational tasks to obtain rewards (e.g., earning a high grade, winning a trophy or getting approval) or to avoid punishment (e.g., earning a low grade, loosing a trophy, not getting
approval). Their motivations tend to focus on such performance goals as obtaining positive judgments of their competence or avoiding unfavorable judgments of their competence from peers, teachers, and parents (e.g., Ames & Archer, 1988; Csikszentmihalyi & Nakamura, 1984; Duda & Nichols, 1992; Reeve, 1996).
CHAPTER 2
THEORETICAL FRAMEWORK

Empirical Research on the van Hiele Theory

Usiskin (1982) and Fuys, Geddes, & Tischler, (1988) confirmed the validity of first four levels (recognition, analysis, abstract, and deduction), except level-V (rigor) with high school students. They found that levels-I through IV are testable, but level-V is not testable and does not exist at the high school level. This level is more appropriate for college students. According to Usiskin (1982), most students can be assigned a van Hiele level by giving a simple multiple-choice test, although students in transition between two levels are difficult to assign reliably (Gutierrez & Jaime, 1998).

Many students who participated in the study by Usiskin (1982) are not successful in geometry. One key factor behind this failure is the quite poor knowledge of students who do not have enough geometry background from the middle school. In addition, many lack motivation for learning even the simplest geometry knowledge in high school. Therefore, most leave the geometry course without knowing basic terminology and basic principals (Usiskin, 1982).

According to Usiskin (1982), the geometry course is not working for large numbers of students. In addition, he pointed out that many students do not have even trivial
information regarding geometry terminology and measurement at the end of their year of study of geometry. He concluded “If we want our students to have greater geometry knowledge and proof-writing success among students, we have to support them with systematic geometry instruction before high school” (p.89).

Usiskin (1982) confirmed the use of the Van Hiele theory to explain why many students have trouble in learning and performing in the geometry classroom.

The vast majority of students can be assigned a Van Hiele level by a single test even though the Van Hiele level theory has yet to be explicated in a way that enables the testing of its highest level or the assigning to each student a unique level. The levels assigned to students are a good descriptor of concurrent student performance in geometry and a reasonably good descriptor of later performance. The poor performance of many students either on a geometry content test or in proof writing is strongly associated with being at the lower Van Hiele levels (Usiskin, 1982, p. 89).

Mayberry (1983) conducted a study of 19 pre-service elementary school teachers. The tasks employed in her study was designed for the first four levels including seven geometric concepts that were squares, right triangles, isosceles triangles, circles, parallel lines, similarity, and congruence. The study was to test the following hypotheses: “H1- For each geometric concept, a student at level N will answer all questions at a level below N to criterion but will not meet the criterion on questions above level N. H2- a student will meet the criterion at the same level on all geometric concepts tested” (p.58).

Van Hiele (1986) underlined two implications of his theory: (a) A student cannot perform adequately at a given level without knowing the knowledge of the previous level that enables him/her to think intuitively at each preceding
level. (b) If the student’s thought level is lower than the language of instruction, s/he will not understand the instruction. According to the results of Mayberry’ study (1983), it appears that the first statement was supported by the acceptance of H1. It seems that “the finding that 70% of the response patterns of the students who had taken high school geometry were below level-IV (deduction)” (p.68-69) supports the second statement of van Hiele. In addition, the response of patterns showed that students who took part in the study were not at the suitable level to understand formal geometry, and that the instruction they had taken had not brought them to level IV (Deduction). Responses of the students implied that the typical student in the study was not ready for a formal deductive geometry course (Mayberry, 1983). She added, “If further confirmation is found for the hierarchical nature of levels and if the phases of the movement from one level to the next higher level are identified, then appropriate experiences can be designed to help students make orderly progress. To implement these experiences, the teacher must determine the level at which a student is functioning” (p.68).

Burger and Shaughnessy (1986) examined the specific questions related to the van Hiele theory of learning in geometry. The first one was regarding the usefulness of the van Hiele levels in describing students’ thinking processes on geometry tasks. The second one was to find out if the levels could be characterized operationally by students’ behavior. The third one was about designing an interview procedure that could reveal predominant levels of reasoning on specific geometry tasks. They found that the van Hiele
theory of reasoning was helpful in describing students’ responses on the geometry tasks. They said, “This is significant to researchers for its value in describing behavior. It is also significant to teachers in selecting and sequencing instructional activities in accordance with the model” (p.27). Moreover, they confirmed much of van Hiele’s description and characteristic of the levels. They also said that van Hiele theory could serve as a basis for constructivist teaching experiments in geometry. According to them, the van Hiele levels, visualization, analysis, abstract, deduction, and rigor were useful in describing students reasoning processes on polygon tasks. Therefore, they suggested that educators and researchers could make task assignments based on the levels with little sophisticated data, and it could be suitable to examine students’ answers. These tasks included geometry concepts, such as similarity, measurement and congruence between figures. Henceforth, van Hiele theory of reasoning in geometry was verified. Although students’ behaviors on tasks, such as drawing, identifying and defining shapes, and establishing properties of any figures were consistent with the van Hiele levels, level-V (rigor), which involves combining different theorems and comparing different systems was not confirmed (Burger & Shaughnessy, 1986).

Fuys, Geddes, & Tischler (1988) pointed out that the learner has to go through the levels consecutively; otherwise s/he will not be able to perform the tasks. In that, they all agree on the importance of following the order of the theory’s levels in geometry. In addition, all teaching methods do not equally allow students to attain higher levels because of the difference of students’
learning styles. It is also possible to face a discrepancy between a student and a teacher who operate at different thinking levels. For example, a student at level-I or level-II sometimes may not understand concept taught at level-III or IV.

Fuys et al. (1988) concluded that each van Hiele level has its own linguistic symbols with their own systems of relations. They added that language structure is a key factor in the progress through the Van Hiele levels from concrete (level-I), to abstract structures (level IV-V). In stressing the importance of the language, they attributed many failures in teaching geometry to language barriers. Moreover, they claimed that the progress from one level to the next more depends on instruction than on the student’s age or biological maturation; that instructional experiences are also important for progress.

Gutierrez, Jaime, & Fortuny (1991) studied with 9 eighth graders and 41 pre-service elementary teachers and supported their proposal with an example of the application of the method which evaluates students’ ability to reason in three-dimensional geometry. The major goal of their study is to show an alternative way to evaluate the levels of students who are between two levels. According to them, this method allows educators and researchers to determine the students’ degrees of acquisition of the van Hiele levels.

According to Burger & Shaughnessy (1986), the progress through the levels is continues, not discrete. Therefore, Gutierrez et al. (1991) set their research based on the following two arguments “(a) to have a more complete view of the current geometrical reasoning of students, we should
take into account their capacity to use each one of the van Hiele levels, rather than assign a single level. (b) Continuity in the van Hiele levels means that the acquisition of a specific level does not happen instantaneously or very quickly but rather can take several months or even years” (p.238).

Gutierrez et al. (1991) used a 100-point numerical scale between levels. This numerical scale is divided into five qualitative scales: “Values in interval” (0%, 15%) means “No Acquisition” of the level. “Values in the interval” (15%, 40%) means “Low Acquisition” of the level. “Values in the interval” (40%, 60%) means “Intermediate Acquisition” of the level. “Values in the interval” (60%, 85%) means “High Acquisition” of the level. Finally, “values in the interval” (85%, 100%) means “Complete Acquisition” of the level” (p.43).

Gutierrez et al. (1991) used the assessment instrument as a spatial geometry test that evaluated the students’ van Hiele levels on three-dimensional geometry tasks. They came up with the conclusion that the van Hiele theory needs to be adapted to the complexity of the human reasoning process because people do not have a simple and linear thinking process. In addition, they understood that some students used several levels of reasoning at the same time; this might be due to the difficulty of the problem. According to their findings, it is interesting to note that although lower levels are generally acquired more time completely than upper ones, some students at Level-III than at Level-II. A deeper study is therefore necessary to figure out the cause of this happening: errors in the test, methods of
evaluation, or the teaching methods? (Gutierrez et al., 1991).

Geddes & Fortunato (1993) recommended that for middle grade students, geometry teachers must focus on level-I (Visual), level-II (Analysis) and level-III (Informal deduction) of the van Hiele theory. He said that most of the commercial textbooks for middle graders contain one or two chapters on informal geometry. However, teachers are not giving enough attention to these chapters, and most teachers frequently delay teaching geometry. He suggested that if students are having trouble learning geometry, one might hypothesize according to the model that they are being taught at a higher level than they have accomplished. In addition, two individuals (teacher and student, or student and textbook author) who reason with different linguistic symbols and use different relationships, find communication very difficult. It is a great challenge to teach students at different levels in the same class (Hoffer, 1986).

According to Geddes & Fortunatos’ study (1993), in recent years, several researches examined and verified aspects of the Van Hiele model in relation to the middle grades. These projects have developed geometry activities and experiences based on the van Hiele theory in order to assist students in gaining deeper insight and higher order thinking skills. In this perspective, Clements & Battista (1990) suggested that Logo environment might help children improve geometric conceptualization and reasoning ability. They posited the usage of a Logo oriented geometry curriculum in schools because it has the potential of improving children’s learning. In addition, Hoffer (1986)
claims that hands-on activities usually help students performing at level-I (Visualization) move toward level-II (Analysis).

Van Hieles (1986) proposed a sequence of five phases of instruction that are a) inquiry, b) direct orientation, c) explicitation, d) free orientation, and e) integration. According to Hoffer (1986) and Geddes & Fortunato (1993), these phases do not have to be linear. Students frequently cycle through some of the phases several times before attaining a new domain of reasoning; thus reach the next level.

Mason (1997) conducted a research project on the geometric understanding and reasoning of 120 mathematically talented students in the 6th through 8th grades. Her study described and analyzed the responses of those students who took van Hiele Geometry test and 64 of those who participated in 30-45 minute individual interviews.

Mason (1997) posited that although these gifted students are in the sixth through eighth grades, their performance on the van Hiele geometry test are higher than that of those who enter a high school geometry course. She gave an example that gives detail information about the van Hiele levels of those gifted students in comparison to the other students who participated to Senk’s study as Senk (1989), using this same CDASSGP instrument with students beginning a high school geometry course, found that of the 241 students in 11 schools in 5 states who “fit the model” according to the test results, 27% had not mastered level 1, 51% mastered level 1, 15% mastered level 2, 7% mastered level 3, only one student (.4%) mastered level 4, and no students had mastered level 5. Of the 77% gifted students who “fit the model” in the current study, only 5% had not mastered level 1 and 17% were classified as having attained van Hiele levels 4 or 5. In Senk’s study, only 22% were above level 2; 49% of the gifted students in the current study were above level 2. (Mason, 1997, p.45).
According to her study (1997), the mathematically talented middle school students on the van Hiele levels are statistically significantly different from the high school students in Senk’s study. Furthermore, in her study she found that the van Hiele levels are hierarchical in mathematically talented students. Although these subjects in her study are middle school students, 35.8% of them skipped levels in the van Hiele theory. She wrote “Mathematically talented students should be placed in classes where they can receive an appropriately challenging education, but placing students who are not ready for geometry in the class early does the students a disservice. Before placing students into geometry, some indicators of success in geometry, such as the students van Hiele levels of geometric understanding and their geometry content knowledge, should be assessed” (p.51).

Although there is a paper and pencil multiple-choice test (designed by Usiskin (1982)) in which items are used to evaluate the students’ reasoning levels based on right or wrong answers in geometry, Gutierrez and Jaime (1998) carried out new research about an alternative assessment test with 309 students from grades 6 to 12 in Spain. They said that researchers agreed that the most accurate way of assessing van Hiele levels is to make a clinical interview, because it gives more detail information about students’ ways of reasoning than other procedures. However, it is time consuming and not feasible. On the other hand, multiple-choice tests are efficient and not time consuming. They sought the answers of the following questions; “(a) What type of test should be used? And (b) how should the student’s responses be evaluated?” This time they studied
on the 2-dimensional as opposed to 3-D geometry they did in 1991.

Gutierrez et al. (1998) reported that many 6\textsuperscript{th} and 10\textsuperscript{th} (2\textsuperscript{nd} Secondary) students did not complete acquisition of level-I, but they progressed toward acquisition of level-II. Third and fourth year secondary school students showed the same behavior between levels-II and III. They posited that this finding about the hierarchical structure of the van Hiele levels is in contrast with the claim of Van Hiele (1986) who said, “the ways of thinking of the base level, the second level, and the third level have a hierarchic arrangement. Thinking at the second level is not possible without that of the base level; thinking at the third level is not possible without that of the second level” (p.51).

They finally concluded that their test is not intended to assess a fixed van Hiele level, “but the use of some of the process integrating the levels” (p.45). The test with 309 students from 6\textsuperscript{th} through 12\textsuperscript{th} grades demonstrates small differences in the levels of reasoning of different students. They claimed that these differences would not have been discovered by the classical methods. Therefore, “this technique of assessment is clearly an advance in the use of the van Hiele levels” (Gutierrez et al., 1998, p.45).

Usiskin (1982) found that the van Hiele levels of most students who studied proof in geometry classes showed poor performance. He also said, “Of all high school students in the United States, approximately: 60% do not study proof. 47% of this do not take geometry, 6% take geometry but drop out before finishing, and 7% are enrolled in a non-proof geometry course. 40% study proof. 11% study proof but can
not do anything with it, 9% can only do trivial proofs, 7% have moderate success with proof, and 13% are successful with proof” (p.88). Furthermore, he posited that gender does not have an effect on learning geometry from facts through proof. In other words, the ability to learn geometry at the high school level is equal between the sexes from facts through proof. Although the performance of boys on multiple-choice tests of content at the beginning of the year and at the end of the year are significantly higher than that of girls, the sex differences disappear at the end of the year if the scores are adjusted for entering geometry knowledge (Usiskin, 1982).

Senk (1989) examined the relationship between the achievement in writing geometry proofs and the achievement in standard geometry content with regard to Van Hiele levels. For that purpose she revisited some parts of CDASSG project (Cognitive Development and Achievement in Secondary School Geometry) on which Usiskin (1982) had previously worked. Of the 2699 students involved in initial project, she only took 241 from 11 schools in five states.

Senk’s study (1989) showed that there is a positive relationship between high school students’ achievement in writing geometry proofs and van Hiele levels of geometric thought regarding achievement on standard non-proof geometry content. According to her, a student who starts a high school geometry course does not show level-I geometry knowledge or is not able to visualize shapes of common plane geometric figures (level-0) has little chance of learning to write geometry proofs later in the year. One who at the beginning of the year is able to visualize the shapes of geometric figures but is not able to describe
their properties (level-I) may successfully do some simple standard geometry proofs by the end of the year; but such a student has a slight chance of mastering proof writing. However, a student who performs level-II geometry knowledge or is able to visualize the shapes of geometric figures and able to describe their properties has a fifty percent chance of mastering proof writing by the end of the year. In addition, a student who is able to show level-III geometry knowledge or is able to reason from the properties of geometric figures and see the relations between them has a greater chance of mastering proof writing by the end of the year.

According to van Hiele (1986), level-III is a transitional stage between informal and formal geometry. Geometry knowledge at this level is constructed by short chains of reasoning about properties of a figure and class inclusions. A Student who functions at this level is able to follow a short proof based on properties gained from concrete experiences, but s/he is unable to construct a proof by her/himself. If students perform the level-IV or -V geometry knowledge then they will be able to do and write formal proofs. The study showed that although there is no individual Van Hiele level that grantees future success in proof writing, Level-II seems to be the critical entry level. Senk concluded, “the predictive validity of the van Hiele model was supported. However, the hypothesis that only students at level-IV or-V can write proofs was not supported” (p.309).

Usiskin & Senk (1990) expressed their surprise at the results of the Senk’s study (1989) about the positive correlation between van Hiele levels and proof writing.
They said that the van Hiele geometry test (25-item multiple-choice test) could be used to predict the student’s ability to write proof. However, according to a study by Mason (1997) with the talented students from grade 6th to 8th, although 35.8% of these students skipped levels in the van Hiele model, “many of these mathematically talented subjects had not been exposed to or did not remember what the critical defining attributes of various figures were” (p.50). In addition, they do not know how to write an acceptable formal proof, they are not familiar with the role of axioms and definitions, and they do not know the meaning of necessary and sufficient conditions. Deductive reasoning is a major characteristic of mathematically talented students that can be “developed outside the context of geometry, as it apparently has with many of these subjects” (Mason, 1997, p.51).

Swafford, Graham, & Thornton (1997) conducted a research study with forty-nine middle grade teachers (4 through 8) for a 3-year professional development project supported by the National Science Foundation. The study investigated the impacts of an intervention program on instruction. The intervention program was designed to increase teachers’ geometry content knowledge and their knowledge of research-based findings on students’ cognition in geometry. Each year of the project contains a 4-week summer session and six half-day seminars during the academic year. Each summer the program focused on a different subject matter content in geometry. The teachers met 3 hours a day for 4 days a week, and a research seminar about the van Hiele theory and its philosophies that occurred 2 hours once each week. The researchers divided
the participants into two groups. Group 1 consists of the grades 4–5 teachers and group 2 consists of the grades 6–8 teachers. In addition, these researchers selected eight teachers from each group for video observations and stimulated recall interviews during the academic year following the summer course.

The study of Swafford et al. (1997) found that an intervention program that enhanced teachers’ geometry content knowledge and their knowledge of research based findings on students’ cognition in geometry could affect instructional practices in the geometry classes. Especially, the impact on instructional practice of increased geometry knowledge and research-based knowledge of students’ cognition in geometry was evident in what was taught, how it was taught, and the characteristics teachers displayed.

They (1997) claimed that an intervention program changed the teachers’ teaching style and their approaches to their students in the mathematics classes. Teachers spent more and quality time in teaching geometry, in particular in the use of rich problems and geometrical tasks. In addition, having enhanced knowledge of geometry and learned the van Hiele levels and its philosophies gave more confidence to the teachers and encouraged them to take more risks and use hands-on approaches and manipulative in their teaching of geometry.

**Summary**

Usiskin (1982), Mayberry (1983), Burger & Shaughnessy (1986) and Fuys et al. (1988) confirmed the validity of first four levels of the geometric thought (visualization,
analysis, abstract, and deduction). They all agreed that the last level, rigor (level-V), was not suitable for high school students. It was much more appropriate for college students. Moreover, Clements & Battista (1990) defined and described level-0 (Prerecognition) as a basic level.

Van Hiele (1986) expressed two implications of the theory: a) students can not show adequate performances at a level without having had experiences that enable students to reason intuitively at each preceding level. b) a student will not understand the instruction if the student’s reasoning level is lower than the language of instruction. Mayberry (1983), Burger & Shaughnessy (1986) and Fuys et al. (1988) all support statements (a) and (b). Van Hiele levels are hierarchical, and the progress from one level to the next is continuous. Furthermore, students’ performance may vary from one concept to another in van Hiele theory. Concept formation in geometry may occur over long periods of time and requires specific interaction (Mayberry, 1981/1983; Gutierrez et al., 1998). Moreover, Burger & Shaughnessy (1986) said that the Van Hiele levels of reasoning could function as a basis for constructivist teaching experiments in geometry.

Burger and Shaughnessy (1986) found mostly level-I reasoning in grades K-8 while Fuys et al. (1988) found no one performing above level-II in interviewing sixth and ninth grade average and “above average” subjects, which supports the idea that most younger students and many adults in the United States reason at levels-I (Visualization) and -II (Analysis) of Van Hiele theory (Usiskin, 1982; Hoffer, 1986).
Motivation and Middle School Mathematics Students

Many internal and external factors, such as feeling valued, perception of cognitive competence, benefits and threats from peers and teachers, perception of parents’ support, environment, task difficulty, real-life activities, gender, instruction, perception of success, fear of punishment, etc., appear to play prominent roles in students’ motivation in mathematics classroom (e.g., Reeve, 1986; Driscoll, 1994; Meyer, Turner & Spencer, 1997; Wentzel, 1997/1998; Stipek, 1998; Rogers, Galloway, Armstrong & Leo, 1998; Middleton, 1999; Alderman, 1999; Gottfried, Fleming & Gottfried, 2001). Middleton & Spanias (1999) reviewed studies on motivation in mathematics. They discussed results of research perspectives, and gave broad information regarding consistencies and criticisms about them. In particular, they focused on generalization about contextual factors, cognitive processes, and utility of interventions that influence students’ and teachers’ motivations, and the lack of theoretical guidance. After examining the findings of research perspective regarding motivation, Middleton & Spanias (1999) came to several conclusions. They found that students’ perception of success in mathematics had a great impact in forming their motivational attitudes. According to Ryan & Pintrich (1997), students’ perception of their cognitive competence in mathematics was positively related to mathematics achievement.

According to Middleton & Spanias (1999), teachers’ actions and attitudes developed earlier and highly stabilized overtime affect students’ motivation toward mathematics. Stipek (1998) highlighted the importance of
the teachers’ care on students’ motivation and performance. Wentzel (1997) also studied these motivational factors. The study examined the role of perceived pedagogical caring at middle school level with 248 students from grades 6 to 8. She particularly sought to answer the following questions; “(a) to what extend do adolescents’ perceptions of caring teachers predict efforts to achieve positive social and academic outcomes at school? (b) How do middle school students characterize a caring, supportive teacher?” (p.411).

Wentzel (1997) found that teachers’ caring was significantly and positively related to students’ pursuit of prosocial and social responsibility goals, and academic effort. In addition, perceived caring from teachers had significant and positive effect on students’ internal control beliefs, but negative one on their distress. She stated “perception of supportive and caring relationships with teachers are important regardless of students’ race or family background”; that “students’ perceptions of caring reflect general levels of social competence and ability to form positive relationship with others” (p.417). Wentzel & Asher (1995) supported this finding by showing that students who do not have friends, but are well liked by teachers are highly motivated to accomplish academically. She (1997) claimed that they were willing to engage in classroom activities if they felt supported and valued by their teachers.

The study by Middleton & Spanias (1999) revealed “providing opportunities for students to develop intrinsic motivation in mathematics is generally superior to providing extrinsic incentives for achievements” (p.90).
This finding is in agreement with the claim of Dev (1998) who wrote that intrinsic motivation was more important in students’ learning than extrinsic motivation. For instance, if a student was intrinsically motivated, s/he could often achieve more than expected as expressed in “retention and generalization improve when learning is intrinsically motivated rather than extrinsically motivated” (p.98). She also thought that there was a significant relationship between students’ achievement or performance and academic intrinsic motivation (Dev, 1998).

According to Stipek (1998), the nature of the instruction and the given task strongly impact students’ motivation. Clear and meaningful task activities, active participation and level of difficulty are factors that hinder or facilitate learning. Middleton & Spanias (1999) corroborate this idea when they say that well carefully structured instructional design has great influence on achievement in mathematics.

Middleton (1995) investigated the relationship between teachers’ and students’ personal constructs with respect to intrinsic motivation in the mathematics classroom. The study took place in a real classroom environment. There were five middle-school mathematics teachers (one sixth grade, two seventh grade and two eighth grade) volunteered and a total 30 students (six from each level). Students in the classes were ranked according to their degree of motivation. Each teacher selected six students from the upper end and from the lower end. The researcher was interested in a) “the ways in which teachers attempted to build student motivation into their lessons” and b) “the belief systems of teachers as compared to those of their
students” (p.254). He observed, videotaped each class for one-43 minute period and interviewed each teacher individually. Then, “in a repertory grid task, students and teachers were asked to distinguish what they believed makes mathematics motivating” (p.254).

According to Middleton (1995), teachers and students built similar beliefs constructs with regard to intrinsic motivation in mathematics classes. The main concerns of both highly and low motivated students revolt around themes of arousal and control, as were teachers. Middleton (1995) claimed, “it seems that the more highly motivated students tended to focus on higher arousal and less control in evaluating activities, whereas the less motivated students tended to focus on lower arousal and more control.” (p.273). In addition, overall, teachers made poor prediction about their students’ motivational constructs. They usually developed their lesson plans based on the level of their least motivated students or the class average, and usually gave them more attention in order to reduce the complexity of preparation (Middleton, 1995). He furthermore claimed, “teachers’ personal constructs of what makes mathematics intrinsically motivating do seem to play a major role in the types of activities and examples they choose and design” (p.277). Teachers in this study believed that real-life examples or activities were major motivating factors in mathematics classroom. He added that it seems that using real-life applications, group practices, hands-on activities, and other strategies played important roles in the students’ motivation.

An important point made by Middleton (1995) with regard to stimulation in mathematic was that “what teachers
feel is novel, challenging, or requires imagination will determine to a large degree what they incorporate in their lessons” (p.277). All the teachers who participated in the study intended to and successfully challenge their students. They used different ways, tasks, and tools, such as puzzles, problem-solving stations to motivate their students. He concluded in his study (1999) “In general, the better teachers were at anticipating the motivational structures of their students, the better they were at providing an environment that facilitated the development of intrinsic motivation” (p.349). This shows that environment is crucial to students’ motivation (Stipek, 1998).

Wentzel (1998) analyzed the role of parents, teachers, and peers in relation to social relationships and motivation with 167 sixth grade students. She demonstrated that students’ motivation in relation to the perceived support from parents, teachers, and peers showed differences based on the source of support and motivational outcome. She found that teacher support was considered an independent and positive predictor of the two types of interest and social responsibility goal pursuit. In addition, family cohesion and perceived support from teachers were also independent and positive predictors of interest in school. Thus, she writes, “Interest in school has been identified as a powerful motivational construct related to the formation and regulation of goal-directed behavior” (p.203). However, perceived support from parents and peers was indirectly related to interest in school.

According to Wentzel’s study (1998), peer support was perceived as an independent and positive predictor of
prosocial goal pursuit, and teacher support was considered an independent and positive predictor of social responsibility goal pursuit. Furthermore, she argued that family cohesion was considered an independent and positive predictor of mastery and performance goal orientations. She writes, “Goal orientations represent reasons why students try to achieve academically ... mastery goal orientations represent desires to achieve outcomes derived from the actual process of learning, such as feeling of satisfaction and competence... performance goal orientations represent desires to achieve outcomes derived from personal expectations or values associated with the consequences of task engagement.” (p.202).

Wentzel (1998) overall concluded that parents, teachers, and peers appear to play relatively independent roles in children’s lives, and impacts of having multiple sources of support on motivational and academic outcomes were primarily additive rather than compensatory. This is in agreement with the claim of Stipek (1998) who said that teachers have great opportunities to affect students’ motivation to accomplish in school. Parents were influential, but teachers were more influential on students’ motivation than the parents because teachers have control of most aspects of instruction, and the social climate of the classroom. Therefore, they can easily enhance their students’ motivation and performance in mathematics (Stipek, 1998).

Middleton (1999) carried out a follow up study with two middle schools mathematics teachers who participated in the previous study (1995) on constructs of teachers’ beliefs regarding what makes mathematics intrinsically
motivating. He analyzed representations of teachers’ beliefs before and after a year of instructional practice with respect to middle school curricula organized around the principles of Realistic Mathematics Education (RME). According to his study (1999), teachers claimed that students made deeper thinking and showed greater performance while they were engaged with difficult tasks. After struggling with difficult materials, students gained more confidence, and more students became successful. He claimed that positive changes on students made positive impacts on teachers’ personal constructs. Relich (1984) said that if students could understand that their successes were valuable and result from both their abilities and a high degree of effort, they were more likely to believe that they could do mathematics if they tried.

He also concluded that RME-based materials have a great influence on teachers’ attitudes that is not in contrast with the claim of Wubbels, Korthagen & Broekman (1997). They said that students who were engaged with RME-based materials involved in more classroom discussion and received more response from the classroom teachers than they had the classes not using RME-based materials.

Wermeer, Boekaerts & Seegers (2000) examined 158 (79 boys and 79 girls) sixth-grade students’ mathematical problem solving behavior on two types of mathematics tasks, computations and applications, in regard to motivation and gender issues. They found that differences in mathematical problem-solving behavior mostly depended on contents of the mathematics tasks and on gender. They also added that students’ performance on task appraisal and learning
intention were greater for computation problems than for application problems.

Middleton & Spanias (1999) wrote, “Inequalities exist in the ways in which some groups of students in mathematics classes have been taught to view mathematics” (p.90). The study by Wermeer et al. (2000) showed that boys and girls displayed different motivational orientations toward mathematics in general and toward applied problem solving in particular. They found that boys’ performance was better than girls, and boys displayed higher confidence during applied problem solving session. However, there were no sex-related differences found between boys and girls on computation problems. Girls showed higher persistence than boys, but only during applied problem solving session.

Anderman, Maehr & Midgley (1999) conducted a 3-year study with 278 fifth-, sixth- and seventh-grade students coming from two different types of middle schools. One of these was characterized as utilizing task-focused instructional practices, and described as “principals were familiar with the emerging recommendations for reforming middle-level schools and had encouraged some team teaching, occasional interdisciplinary projects, more flexible use of time…”, while the other school utilized more traditional practices “… including a departmentalized organization with relatively powerful department heads… ability grouping pervasive, … strong messages about the importance of grades and test scores” (p.133). The study sought the impacts of the transition from elementary-to middle schools on the motivational beliefs of students. Teachers in the latter school particularly emphasized competition, ability grouping, and students’ relative ability.
Anderman et al. (1999) posited that there were several differences in students’ motivational beliefs when students were in elementary school. Attending two different middle schools made different impacts on students’ motivational beliefs. In particular, students who attended the school placing a greater attention to competition and ability differences showed higher mean levels of personal performance goals and personal extrinsic goals after transition. Moreover, an increase can be seen from the table in perception of an emphasis on performance goals and extrinsic goals between fifth and sixth grade students who attended the traditional one. In contrast, there was a decrease in perceptions of an emphasis on performance goals and motivations between fifth and sixth grade students attending to the school that used more task-focused instructional practices.

Stipek (1998) claimed that “students’ motivation is also affected by the social context- for example, whether students feel valued as human beings, are supported in their learning efforts by the teacher and their peers, and are allowed to make mistakes without being embarrassed.” (p.16). Ryan & Pintrich (1997) gave an explanation to Stipek’s claim in their study. They (1997) investigated motivational effects on help-seeking behavior in math classroom and students’ perceptions of benefits and threats associated with such behavior. There were 203 seventh and eighth grade students involved in the study responding to a questionnaire including perceptions of social and cognitive competence, achievement goals, attitudes, and avoidance of and adaptive help seeking behavior. They identified avoidance of help-seeking as “when a student needs help but
does not seek it”, and adaptive help-seeking as “a student asking for hints about the solution to a problem, examples of similar problems or clarification of the problem” (p.329). They (1997) found pattern of results among motivational variables (achievement goals, task-focused, extrinsic, relative ability, perceptions of competence, social and cognitive), help-seeking attitudes (benefits, threats from peers and threats from teachers), and help-seeking behaviors (adaptive help-seeking and avoidance of help-seeking). They also concluded that there were significant negative correlations between avoidance of help-seeking and task-focused goals, cognitive competence and benefits, and significant positive correlations between adaptive help-seeking and task-focused goals, cognitive competence and benefits. Moreover, there were significant positive correlations between avoidance of help-seeking and extrinsic, relative ability goals, threat from peers and teachers, whereas there were significant negative correlations between adaptive help-seeking and extrinsic goals, threat from peers and teachers. There was also a negative relationship between math achievement and avoidance of help seeking (Ryan & Pintrich, 1997).

Gottfried, Fleming, & Gottfried (2001) analyzed the continuity of academic intrinsic motivation from childhood through late adolescence in a longitudinal study, initiated in 1979, with 96 students at ages 9, 10, 13, 16 and 17 respectively. They obtained positive, significant indirect effects for academic intrinsic motivation between successive years in both the general and math models. They also found that academic intrinsic motivation not only had direct impacts from one age to the next and had an effect
on students’ motivation at subsequent ages through motivation at earlier ages. They said that academic intrinsic motivation was a stable construct from childhood through late adolescence becoming increasingly stable for both math and the general-verbal areas. In addition, their study indicated that academic intrinsic motivation declined significantly from middle school through late adolescence. The greatest decline was obtained for math among the other areas, such as science, reading and social studies.

Stipek (1998) claimed that “fear of punishment, such as public humiliation of low grades can motivate positive work behaviors, but it also can cause anxiety and alienation, which hinder learning” (p.30). Moreover, she wrote, “students who believe that they are academically competent are more intrinsically interested in school tasks than those who have low perceptions of their academic abilities” (p.121).

Summary

Middleton & Spanis (1999) stated that students' perception of success in mathematics had a great effect on students' motivational attitudes. Wentzel (1998) posit that parents' support, peers' help and teachers' care were vital factors playing important roles in students' learning in mathematics. However, Stipek (1998) claimed that teachers had more influence on students' motivation in learning mathematics than parents did because of the fact that students spend most of their times in the schools. In addition, students who felt supported and valued by their teachers were willing to engage in classroom activities and
highly motivated to be successful in the mathematics class (Wentzel, 1997).

The study done by Ryan & Pintrich (1997) showed that students' perception of cognitive competence in mathematics was positively related to mathematics achievement. Moreover, the perception of cognitive competence in mathematics was a prominent factor of gender favoring male students, especially in high school level. In other words, female students at high school perceived mathematics as a male domain (e.g., Fennema & Sherman, 1978; Fennema & Carpenter, 1981; Ethington, 1992), which is aligned with the claim of Gottfried et al. (2001) who found that academic intrinsic motivation declined significantly from middle school through late adolescence in mathematics. However, Fennema & Sherman (1978) concluded that there was no statistically significant gender difference in terms of motivation between boys and girls in mathematics at middle school level.

According to Stipek (1998) and Middleton & Spanis (1999), carefully structured instructional design including clear and meaningful task activities and level of difficulty had a great impact on students' achievement and motivation in mathematics. Similarly, Ryan & Pintrich (1997) and Dev (1998) stated that there was a positive correlation between students' achievement and motivation in learning mathematics.

Briefly, research findings indicated that there were some vital factors such as, environment, perception of teachers' care, parents' support, peers' help, perception of cognitive competence, feeling valued, task difficulty, hands-on activities or real-life activities, perception of
success, fear of punishment, etc., seemed to play important roles in students' motivation in learning mathematics (i.e., Reeve, 1986; Driscoll, 1994; Meyer, Turner & Spencer, 1997; Wentzel, 1998; Stipek, 1998; Middleton, 1999; Gottfried, Fleming & Gottfried, 2001).

Gender Differences in Mathematics Performance

Although there is a difference between the achievement of male and female students in many areas (e.g., Armstrong, 1981; Fennema & Carpenter, 1981; Jones, 1989; Chipman, 1989; Grossman & Grossman, 1994; Smith & Walker, 1988), in recent years a considerable decrease can be seen in the gender gap between male and female students in many, but not all subjects areas (e.g., Friedman, 1994; Feingold, 1988; Hall & Hoff, 1988; Harris & Carlton, 1989; Lynn & Hyde, 1989; Hart, 1992; Fennema & Hart, 1994). However, according to Hyde, Fennema & Lamon (1990), there is also a considerable increase in the gender gap among gifted or high scoring students on the mathematics tests.

According to Fox and Cohn (1980), there was a significant sex difference in mathematics achievement at the high school level. Boys’ performance was better than that of girls on the Scholastic Aptitude Test in mathematics. Similarly, Fennema & Sherman (1978) found sex differences in two out of four high schools in which boys and girls in the same mathematics classes were compared. Smith & Walker (1988) analyzed data of New York State Regents examinations; they concluded that there were statistically significant sex-related differences in favor of male students in geometry at the tenth grade level.
Armstrong (1981) examined and compared two data sources. The first one was a survey, which was the women in mathematics project, conducted in the fall of 1978 by the Educational Commission of the States (ECS). The second one was from the second mathematics assessment conducted during the period 1977-1978 by the National Assessment of Educational Progress (NAEP). The participants who were at the ages of 9, 13, and 17, were evaluated based on participation and achievement. She found that “sex differences in achievement for the 12\textsuperscript{th} -grade sample favored males on all four subtests, but the only statistically significant difference was on the problem solving subtest, on which males scored approximately seven percentage points higher. There were no significant sex differences on the spatial visualization measure.” (p.361). Armstrong’s finding were similar to Fennema & Carpenter’s study (1981), which found that at age 17 there was a sex-related achievement difference favoring male students whose average performance in mathematics was slightly higher than that of female students at every cognitive level.

Armstrong’s study (1981) showed that thirteen-year-old girls performed better at computation and spatial visualization than boys did. The problem-solving abilities of boys and girls at this age were nearly equal but slightly favored boys. Moreover, 13-year-old girls began a high school mathematics program with the same skills as boys. However, she found that this phenomenon had changed by the end of the high school. The twelfth grade boys outperformed their counterparts in problem solving, and girls were not successful in computation and spatial visualization. Although boys performed better at routine
one-and two-step word problems, there were no gender differences in spatial visualization by the end of high school (Armstrong, 1981).

According to Grossman & Grossman (1994), there was a mathematics gender gap in favor of African American, European American, and Hispanic American females in elementary school, but not in the performance of American Indians. In high school, female students performed better than male students on tests involving basic computational mathematics skills with the exception of American Indian girls. However, there was no consistent sex difference in advanced mathematics courses and on tests involving higher-level mathematical skills and word problems. European American male students performed better than European female students. But, according to the report of Yando, Seitz, & Zigler (1979) on a study of the performance of African American male and female students, they found that the African American females performed better than the African American male students did. Similarly, Asian Pacific/Islander female students also outscored Asian Pacific/Islander males (Grossman & Grossman, 1994).

Fennema & Carpenter (1981) investigated sex-related differences among 9, 13 and 17 year old mathematics students on the Second Mathematics Assessment of the National Assessment of Educational Progress in which there were four content areas and four cognitive levels assessed. Content areas were comprised of number and numeration, variables and relations, geometry, measurement, and other topics. The cognitive levels were knowledge, skill, understanding, and application. They said, “at ages 9 and 13, there was a consistent pattern of lower averages for
females on geometry and measurement exercises over all cognitive levels; knowledge, skill, understanding, and application” (p.556). In particular, this difference for measurement was large. In other words, they concluded that girls at the middle school level showed poor performance on geometry and measurement exercises involving spatial visualization skills. They supported their conclusion with the finding of Maccoby & Jacklin (1974) who stated that from adolescence males showed greater performance than females on items measuring spatial visualization skills. However, female students at ages 9 and 13 scored higher than male students on numerations skills. In addition, Armstrong (1981) claimed that the California Assessment Program (CAP, 1978) indicated no differences in the achievement of boys and girls in the sixth grade level in the skills of measurement applications, geometry applications, and probability/statistics, but in the twelfth graders, males scored significantly higher than females.

Harris & Carlton (1989) examined the six recent forms of the Scholastic Aptitude Test (SAT) of 181,228 males and 198,668 females, and they made several conclusions about the gender issue in mathematics. They included two main item types on the SAT-M: regular math or problem solving, and quantitative comparison. They claimed that overall no gender differences were found, but across item types there were some gender differences found with regard to the kind of math being tested. Their study indicated that consistent with past research, boys’ performance were relatively higher than that of girls on geometry and geometry / arithmetic items, while girls performed relatively better
than that of boys on miscellaneous and arithmetic/ algebra items. In addition, according to the researchers (1989), "males found items with a stimulus format (i.e., figure, graph, or table) relatively easier, while females performed relatively better when there was no stimulus format" (p.158).

Harris & Carlton (1989) stated that males showed higher performance on items called for a computed solution, whereas females performed relatively better on items that called for a general solution. They also claimed that males found items requiring higher-level cognitive processing relatively easy, whereas females found routine problems and items requiring lower-level cognitive processing relatively easy. Furthermore, they found that females performed relatively better on the curriculum based items than on word problems, whereas males performed relatively better on items that were less routine than on word problems. This claim was supported by Chipman (1989) in “A Cognitive Science Perspective on Mathematical Ability and Sex Differences Therein”.

Hanna, Kundiger, & Larouche (1990) examined data from the Second International Mathematics Study (SIMS), which consisted of achievement scores for female and male students who were 12th graders. Fifteen countries were involved in the study, which included mathematics achievement for seven mathematics topics. They concluded that there were no significant sex-related differences in mathematics for 19 of the 21 comparisons for Thailand, British Columbia, and England. There were significant sex-related differences in favor of male students for all seven topics for Belgium, Finland, Israel, Japan, and Hungary.
However, there were no significant sex-related differences for sets, algebra, number system, and geometry for the US, but there were significant sex-related differences in favor of male students for probability, analysis, and finite mathematics. The gender in geometry finding of Hanna et al. (1990) is similar to the finding of Senk & Usiskin (1983) the latter stated, “when differences in entering geometry are taken into account, girls and boys learn both geometry problems and proof writing equally well” (p.195). However, Hanna et al. (1990) and Senk & Usiskin (1983) is in contrast with the findings of Smith & Walker (1988) who found that there were significant sex-related differences of males in geometry at the 10th grade level. Harris & Carlton (1989) concluded that boys performed relatively higher than that of girls on geometry and geometry / arithmetic items. These findings were consistent with past research.

Hanna et al. (1990) reported that parental support was an important variable affecting students’ achievement based on gender difference in mathematics. They also said that socio-cultural factors affecting gender related differences in mathematics achievement, such as student confidence and valuing mathematics played a more important role than biological factors.

Grossman & Grossman (1994) explained why female students show poor performance on math tests; “some females who score lower than males on math achievement tests are not less skilled mathematicians. Rather, they score lower because they become anxious when they take such tests and because test items are biased against females” (p.28). Moreover, Nicholls, Cobb, Wood, & Yackel (1989) reported,
“In some perspectives on gender differences in academic motivation, females are seen as having lower expectations of success, valuing success less, and explaining outcomes in different ways. The upshot is a characterization of females as less adaptively motivated than males. In mathematics as well as school in general, students differ (not merely in expectations, explanations, or valuing success) but in what counts as success” (p.151).

Furthermore, Nicholls et al. (1989) claimed that males believed that their success depended on their superior ability, whereas females believed that their depended on collaboration with others and an attempt to understand.

Fennema & Sherman (1978) conducted research with 1,320 sixth through eighth grade students. They focused on variables, such as math as a male domain, confidence in learning math, attitude toward success, spatial visualization, math computation, mathematical concepts, comprehension, application, problem-solving, verbal ability, usefulness, effectance motivation that affect students’ achievement in regard to gender in mathematics. Parental involvement and teacher also affect students’ achievement related to gender differences in mathematics. They found two significant sex-related effective variables, which were confidence in learning mathematics, and math as a male domain. The study also showed that “males were significantly more confident of their ability to learn mathematics than females and that males stereotyped mathematics as a male domain at higher levels than did females” (p.194).

Furthermore, they concluded that there were no significant sex-related differences between males and
females in their intrinsic and extrinsic motivation in mathematics. Their study showed there was no evidence to support the argument that females had less intrinsic and extrinsic motivation in mathematics than did males. In addition, they found no significant sex-related differences in spatial visualization.

Another important finding of Fennema & Sherman (1978) was the pattern of sex-related differences, which was also found in the high school study. They reported, “when sex-related differences in mathematics learning in favor of males were found, sex-related differences in favor of males were also found in six effective variables: mathematics confidence, stereotyping mathematics as a male domain, attitude toward success, perception of mother’s and father’s attitudes toward them as learners of mathematics, and usefulness of mathematics. These differences were found predominantly in Area 3, the area with the highest socio-economic level in the city” (p.198). Fennema & Sherman (1978) found that boys were more confident in themselves with regard to mathematics, and they believed more than females that mathematics was a subject for males. These differences were significant at the sixth grade level and continued into high school.

Ethington (1992) analyzed a theoretical model of achievement behaviors using data from the Second International Mathematics Study. The analysis of the study was based on data from 746 eighth grade students in the US. The focus area was on direct and indirect effects in regard to gender differences in the model of achievement behavior. She reported that prior achievement and value were the only variables that had a significant direct impact on current
achievement for male students. Value was predominantly
determined by goals, perception of parents, self-concept,
stereotyping mathematics as a male domain, and prior
achievement. Effects of the parents’ perception, goals, and
prior achievement were the only indirect impacts on current
achievement. Neither value nor expectations for success had
a significant impact on achievement for females.

The study by Ethington (1992) showed that for both
males and females, the largest indirect impact came from
prior achievement, which was also the strongest direct
influence on current achievement. In addition, the
perception of the parents’ attitudes toward studying
mathematics and the goals related to mathematics were two
indirect impacts for males. Both the perception of
mathematics as a male domain and difficulty had significant
indirect impacts for females, in addition to significant
direct impacts. The impact of both of these variables was
negative. Furthermore, she concluded that females who
perceived lack of encouragement from their parents likely
considered mathematics more difficult, which in turn
resulted in lower levels of achievement. Furthermore,
values were less important for females than males.

Fennema & Sherman (1978) claimed that males considered
mathematics more useful than females did. This difference
began in middle school and continued into high school.
Males considered their parents’ input as a more positive
factor toward learning of mathematics than females did.
This difference began in middle school and continued into
high school. In addition, females perceived their teachers
as being less positive toward them as learners of
mathematics than did males. According to Ethington (1992),
parental support, stereotyping mathematics as a male domain, and perception of difficulty had significantly negative direct effect on achievement for females.

Reys & Stanic (1988) analyzed a model in order to explain group differences in mathematics performance. They proposed that variables such as, societal influence, school mathematics curricula, teacher attitudes, student attitudes, achievement-related behavior, classroom processes, and student achievement played important roles in the performance of students in mathematics.

Becker (1981) conducted research with high school geometry teachers and students in two different high schools. She investigated the interactions of teachers and students (male and female) in geometry classrooms. She supported her conclusion with qualitative and quantitative data. She concluded that there was a differential treatment-taking place in these geometry classes. Becker claimed that even though the teacher students’ interactions were varied, interaction was in favor of the male students. In other words, the teachers in the study treated boys and girls differently in such areas as “(a) afforded response opportunities, (b) open questioning, (c) cognitive level of questioning, (d) sustenance and persistence, (e) praise and criticism, (f) encouragement, (g) individual help, and (h) conversation and joking” (p.50). Again, Becker expressed that in the study female students received less teacher attention, reinforcement, and praise than male students did.

According to Becker (1981), the teacher student interaction was in favor of males. Similarly, Hart (1989) who claimed, “the sex of students was a more important
determinant of teacher-student interactions than was confidence level of students. The direction of mean differences between the girls and the boys showed a great degree of consistency across classes. However, both the size and the number of statistically significant main effects for sex of student were smaller than those found in earlier studies” (p.257).

The study by Underwood (1992) pertained to the pattern of interaction during mathematics instruction with problem solving. The study showed that when students did not question their peers’ answers, there were no gender differences in the interaction patterns. However, when the classmates questioned their peers’ answers, differences in the pattern of interaction it may have been related to the gender of students. During these periods, boys appeared to be more active verbal participants during whole class discussion than girls.

Fennema, Wolleat, Pedro & Becker (1981) conducted research with nine high schools pertaining to gender issue. They applied an intervention program in which there were three objectives; “1- To inform students, teachers, parents, and counselors the usefulness of mathematics, the relationship of mathematics to educational programs and occupations, ... 2- To motivate teachers, counselors, and parents to affect change ... 3-To provide each group with knowledge of specific activities that could help to change students’ mathematics related behavior.” (p.4). They concluded that an education intervention program designed to remedy inequalities in the high school mathematics had positive impacts on female students behaviors toward the mathematics.
In short, Fennema & Hart (1994) examined and summarized the results of the studies conducted on gender issues; the results indicated the following trends in mathematics achievement:

1- gender differences in mathematics may be decreasing
2- gender differences in mathematics still exits in
   • the learning of complex mathematics
   • personal beliefs in mathematics
   • career choices to involve mathematics
3- gender differences in mathematics vary-
   • by socio-economic status and ethnicity
   • by school
   • by teacher
4- teachers tend to structure their classrooms in ways that favor male learning
5- Interventions can achieve equity in mathematics (p.651).

Summary

According to the research findings, there is a difference in terms of performance between boys and girls in many areas of mathematics (i.e., Armstrong, 1981; Fennema & Carpenter, 1981; Jones, 1989; Grossman & Grossman, 1994; Smith & Walker, 1988), in recent years there can be seen a considerable decrease in the gender gap between boys and girls in many, but not all subject areas (e.g., Hall & Hoff, 1988; Harris & Carlton, 1989; Lynn & Hyde, 1989; Fennema & Hart, 1994; Friedman, 1994). However, there is also a considerable increase in the gender gap among high achievers or gifted students on the mathematics tests.

In particular, research findings are also varied at middle school levels. There are some saying that there is a gender gap between boys and girls in learning geometry (e.g., Armstrong, 1981; Fennema & Carpenter, 1981), there are some saying that there is no gender gap between boys and girls on spatial visualization (e.g., Fennema &
According to the study of Armstrong (1981), thirteen-year-old girls performed better at computation and spatial visualization than boys. However, Fennema & Carpenter (1981) investigated gender gap among 9, 13, and 17 year-old mathematics students on the Second Mathematics Assessment of The National Assessment of Educational Progress in which there were four content areas and four cognitive levels, geometry was one of the content areas. They found "at ages 9 and 13, there was a consistent pattern of lower averages for females on geometry and measurement exercises over all cognitive levels; knowledge, skill, understanding, and application" (p.556). In other words, Fennema & Carpenter (1981) concluded that girls at middle school level showed poor performance than boys in learning geometry and measurement. On the other hand, Fennema & Sherman (1978) found that there was no statistically significant sex-related difference in spatial visualization.

There are some factors such as, prior achievement, value, stereotyping mathematics as a male domain, perception of parents' support, perception of teacher care, perception of difficulty, teacher student interaction, etc., appeared to play prominent roles on gender gap between boys and girls in mathematics (e.g., Fennema & Sherman, 1978; Becker, 1981; Ethington, 1992; Grossman & Grossman, 1994). According to Ethington (1992), parental support, perceiving mathematics as a male domain, and perception of difficulty had a significantly negative direct effect on achievement for females. Becker (1981) and Hart (1989) claimed that teacher student interaction was in favor of males. However, Ethington (1992) stated that prior
achievement and value were the only variables that had significant effect on achievement for male students. Neither value nor expectations for success had a significant effect on achievement for females. Fennema & Hart (1994) claimed that interventions could achieve equity in learning mathematics.

**Middle School Mathematics Curriculum Reform**

The Connected Mathematics Project (CMP) was funded by the National Science Foundation to develop and implement a complete middle school mathematics curriculum (6-8). The development, implementation, evaluation and field-testing of the materials took a five - years period. In particular, a large-scale evaluation of CMP materials was conducted in sixth and seventh grades during 1994-1995 and in eight grades during 1995-1996.

According to Ridgway, Zawojewski, Hoover, & Lambdin (2003) based on the CMP results, “no significant differences in growth as measured by the BA Test and ITBS Survey were attributable to gender, teacher, school district, test form, or identifiable variables” (p.205). In other words, they (2003) expressed, “Analysis of other variables showed no significant effects, in particular, for gender, teacher, school district, or test form. Effects were surprisingly uniform across variables other than curriculum used” (p.205). Furthermore, Chappell (2003) claimed that the Balanced Assessment (BA) scores for sixth-grade students using CMP materials increased significantly within a year from pretest to posttest, so did the comparison (non-CMP) students. However, the gains were not significant.
From 1991 until 1998, two institutions, the Wisconsin Center for Education Research at the University of Wisconsin-Madison and the Freudenthal Institute at the University of Utrecht in the Netherlands conducted a research regarding development and implementation of a middle school mathematics curriculum, called “Mathematics in Context (MiC)”. This curriculum MiC consists of 10 units, 10 at each grade level, 5 through 8, teacher’s guide for each unit, a research guide for the entire program, and various supplementary materials. MiC covers the following mathematical strands:

- number (whole numbers, common fractions, ratio, decimal fractions, percents, and integers),
- algebra (creation of expressions, tables, graphs, and formulas from patterns and functions)
- geometry (measurement, spatial visualization, synthetic geometry, and coordinate and transformational geometry), and
- statistics and probability (data visualization, chance, distribution and variability, and qualification of expectations) (p.225).

In 1992, the Netherlands National Institute for Educational Mathematics (CITO) conducted a pilot study comparing the performance of students using realistic text materials with those using traditional materials on 29 mathematics scales. “Geometry/Application” and “Calculating Surface Area, Volume, and Circumference” were among those 29 scales. They reported the results based on a random survey of all students at the end of Dutch primary education (grade 8) (Romberg & Shafer, 2003).

According to Romberg & Shafer (2003), the mean scores of students using RME text materials as to performance on “Geometry/Application” and “Calculating Surface Area, Volume, and Circumference” were numerically lower than
those using traditional materials. In particular, there was a statistically significant difference with regard to performance in “Geometry/Application” part between students using realistic test materials and students using traditional text materials favoring the one who did not use realistic text materials.

“The evidence from the pilot and field tests of MiC, from early case studies of teachers implementing MiC, and from early (and limited) external assessment of the impact of MiC on students achievement, suggests that middle school students being taught by a reform curriculum can and do learn important mathematics” (Romberg & Shafer, 2003, p.249).

Romberg & Shafer (2003) added, “Although our preliminary evidence is encouraging and supports broader implementation of MiC (and by association, of other reform curricula), we also note the need for more complex research and analysis of classroom culture and its impact on student achievement and curriculum implementations” (p.249).

The University of Montana developed a complete middle school (6-8) mathematics curriculum, MATH Thematics (or The STEM Project), sponsored by the National Science Foundation. McDougal Littell published the MATH Thematics curriculum in 1999. They reported the findings of the project as;

1. Students studying from the STEM curriculum do as well as students studying from more traditional curricula as measured by standardized test of traditional content. STEM students perform better than comparison students on items measuring students reasoning, communication, and mathematics problem solving abilities.
2. Use of the curriculum has a positive impact on students’ attitudes toward mathematics.
3. The curriculum is effective with all students (Billstein & Williamson, 2003, p.281).
Billstein & Williamson (2003) said that they administered a 52-item attitude survey to the STEM and Control group students at the sixth grade level as pretest and posttest at the beginning and at the end of each year of field test in order to measure students’ attitudes toward mathematics in reference to motivation, perception of gender differences, problem-solving ability, future interest in studying mathematics, interactions with teachers, communication with and about mathematics, relevance of mathematics to career and adulthood, and use of calculator.

Billstein & Williamson (2003) found a statistically significant shift in one fourth of the items, showing a strong level of measurable effect of the STEM curriculum after a year. Especially, positive growth was detected in students’ attitudes toward their problem-solving abilities, interest in mathematics, and the perception of the importance of mathematics for their future. In addition, Chappell (2003) claimed that the use of the MATH Thematics curriculum materials “had a positive impact on students’ attitudes toward mathematics and especially may have benefited the attitudes of females” (p.290).

According to Billstein & Williamson (2003), “declines in positive attitudes toward mathematics are common among students in the middle school years. The attitude data here suggest that STEM can be a successful form of intervention in curbing the growth of negative attitudes toward mathematics” (p.281).

Reys, Reys, Lapan, Holliday, & Wasman (2003) revealed a research report about the effects of Standards-based curriculums on students’ performance at eight grade level.
They compared the achievement of eighth grade students in the first three school districts in Missouri to adopt NSF-funded Standards-based middle grades mathematics curriculum materials (MATH Thematics or Connected Math Project) with students who had similar prior mathematics achievement and family income levels from other districts. There were approximately 6200 students involved in the study for at least 2 years period (1997-1999). These researches claimed “students using the Connected Mathematics Project or MATH Thematics curriculum materials for at least 2 years on the middle grades equaled or exceeded the achievement of students from matched comparison districts on the mandated state mathematics achievement test. The content strands were Number Sense; Geometric and Spatial Sense; Data Analysis, Probability, and Statistics; Algebra; Mathematical Systems; and Discrete Mathematics.

The study of Reys et al. (2003) found that students using NSF-funded Standards-based curriculum (SB3 implementing CMP materials) had significantly higher scores than nonusers (using traditional textbooks materials) on two of the six content strands: data analysis, probability, and statistics; and algebra.

Reys et al. (2003) concluded that both SB1 and SB2, using NFS-funded Standards-based curriculum MATH Thematics, showed a stronger performance level on all six content strands than those using traditional text materials. In particular, in geometry and spatial sense the mean scores of SB1 (49.17) were numerically higher than that of C1 (43.22). This difference was statistically significant (p < 0.05). Likewise, the mean scores of SB2 (53.18) were numerically higher than that of C2 (47.91). The difference
was also statistically significant (p< 0.05). However, despite the fact that the mean score of SB3 (60.94) was numerically higher than that of C3 (57.27), the difference was not statistically significant.

According to Chappell (2003), Standards-based curricula may have a positive effect on the middle school students’ mathematics achievement in both conceptual and procedural understanding.

In short, these research studies give positive responses to researchers, educators and experts regarding development and implementation of new Standards - based curriculum materials, and support the importance of reform movements in mathematics education at elementary, middle and high school levels (e.g., Huntley, Rasmussen, Villarubi, Sangtong, & Fey, 2000; Thompson & Senk, 2001; Billstein, & Williamson, 2003; Reys et al., 2003; Ridgway et al., 2003; Schoen, & Hirsch, 2003). Furthermore, although research has documented that there is a decline in students’ interests toward mathematics, the findings of the current research studies about the impacts of the Standards - based curriculum materials on students’ performance and motivation have shown that students may overcome their difficulties in terms of achievement, motivation in mathematics (e.g., Billstein & Williamson, 2003; Romberg & Shafer, 2003).
CHAPTER 3

METHODOLOGY

Methods of Inquiry

The quantitative method was employed in this study. According to Creswell (1994), a quantitative approach consists of two types, experiments and surveys. The experimental research embodied the design of this study. There are four types of experimental designs used to investigate cause-and-effect relationships (e.g., Langenbach, Vaughn & Aagaard, 1993; Creswell, 1994; McMillan, 2000). Creswell (1994) describes types of experimental design procedures that are pre-experimental, quasi-experimental, single-subject, and the pure experiment. In pre-experimental design, the researcher does not have a control group to compare with the experimental group. In a quasi-experimental design the researcher has both control and experimental groups for the comparison, but the subjects are not randomly assigned to the groups. In a single-subject design, the researcher observes the behavior of a single individual over a period of time. In a pure experiment, the researcher compares control and experimental groups, and the subjects are randomly selected and assigned to the groups (e.g., Creswell, 1994; Johnson & Christensen, 2000).
In the study the procedure of quasi-experimental design was used. It was with this design, the researcher had a control group to compare with the experimental group, but participants were not randomly selected and assigned to the groups (Creswell, 1994; McMillan, 2000). According to Creswell (1994), the nonequivalent (Pretest and Posttest) control group design model is a popular approach to quasi-experiments. In this design model “the experimental Group A and the control Group B are selected without random assignment. Both groups take a pretest and a posttest, and only the experimental group receives the treatment” (Creswell, 1994, p.132).

Group A: Pretest (O) – Treatment (X) – Posttest (O).

Group B: Pretest (O) – – – Posttest (O).

“X represents an exposure of a group to an experimental variable or event, the effects of which are to be measured. O represents an observation or measurement” (Creswell, 1994, p.131).

The researcher chose the experimental research method because “it provides the best approach to investigating cause-and-effect relationships” (McMillan, 2000, p.207). In the study Pre-and-Posttest were given to the subjects before and after the instruction as an independent variable. The researcher investigated the effects of an instruction using a van Hiele theory based curriculum and gender on students’ performance, and motivation in learning polygons in geometry. The comparison of students’ performance and motivation was made in the study. Therefore, this experimental approach enabled the researcher to evaluate the effectiveness of an instruction
using the van Hiele theory based curriculum with the results of the tests in mathematics classroom.

Participants

In this study the researcher followed the "convenience" sampling procedure defined by McMillan (2000) and Best & Kahan (1986), where a group of participants is selected because of availability. Participants in the study were sixth-grade students enrolled in twelve mathematics classes at two public middle schools in Tallahassee, Florida. The researcher chose these two schools based on their curriculums and permissions of those schools’ principals. One of these was following a van Hiele based curriculum, and the other one was not using a van Hiele based curriculum in their geometry teaching. The total number of students involved in the study was 273. The majority of the students were from low socioeconomic income families.

Data Sources

The data collection processes started with giving students two tests and followed with observation of classes. There were two types of instruments, a performance test called Van Hiele Geometry Test (VHGT) and a questionnaire called Course Interest Survey (CIS) used as Pre-and-Posttests in the study. Both the VHGT and CIS were administered to the participants by the researcher before and after the instruction during a single class period. The Van Hiele Geometry Test (VHGT) consists of 25 multiple-choice geometry questions to be administered in 35 minutes. VHGT was taken from the study of Usiskin (1982) with his
written permission. The VHGT is designed to measure students’ van Hiele levels in geometry. There can be some questions or examples found in Middle School Math Course-1 that are similar to the items in the Van Hiele Geometry Test (VHGT). For example, “Draw an example of each figure... 16. Trapezoid. 17. Parallelogram... 19. Rectangle. 20. Square. 21. Quadrilateral” (p.438). Or, “27. (Problem Solving and Reasoning) Every square is also a rectangle, but every rectangle is not necessarily a square. Explain.” (p.437). This would help to diminish the fact that the test being used was biased towards the curricula designed based on the van Hiele theory.

The Course Interest Survey (CIS) consists of 34 statements categorized into four parts, Attention, Relevance, Confidence and Satisfaction. Using a likert-type rating scale including statements, some positive and some negative, relating to the attitude being measured (Brown & Dowling, 1998), this questionnaire was administered for 15 minutes. The CIS was taken from the study of Keller (1999) by his oral permission. The course interest survey is designed to evaluate a situational measure of students’ motivation in a specific classroom setting. The goal with this instrument is to investigate how students are motivated, or expected to be, by a particular setting. Reliability estimates of CIS were obtained by using Cronbach’s alpha measure for each subscale. They were: Attention: .84, Confidence: .81, Relevance: .84, Satisfaction: .88, Total Scale: .95.

In the study, the permission process from schools and implementation of the pilot study took place during Spring-2002. Students in both groups met one hour a day for 5 days
a week. During the duration of five weeks treatment, the researcher observed each teacher at least twice in order to see whether they follow the curriculum or not. The researcher was passive observant in the classroom. Participation for the written tests was purely voluntary.

**Instructional Curricula**

The instruction following the van Hiele theory based materials used curricula designed on the van Hiele theory. These curricula consisted of *Shapes and Designs* and *Discovering Geometry An Inductive Approach* in which textbook authors wrote their materials based on the first three van Hiele levels (Level-I: Recognition, Level-II: Analysis, and Level-III: Order). The instruction not following the van Hiele theory based on materials used curriculum that was *Middle School Math Course I* covers the first three van Hiele levels’ (Level-I, II, III) geometry knowledge.

The topics consisting of polygons, such as triangles and quadrilaterals, angle relations, properties, and transformation and tessellation were covered during the instruction for 5 weeks.

**Test Administration**

Both VHGT and CIS were administrated in the classrooms by the researcher during a single class period before and after the instruction. CIS was administered the first 15 minutes and followed by 35 minutes of VHGT. Students were told that all of their answers would be confidential. They were also informed that they could guess or ignore
questions that were too difficult. Teachers remained in the classrooms and responded to questions from their students.

Test Scoring

Course Interest Survey (CIS) Scoring Guide: The response scale ranges from 1 to 5. According to this scale, the minimum score is 34 on the 34-item survey, and the maximum is 170 with the midpoint of 102. The minimums, maximums, and midpoints vary for each subscale because the numbers of item distributions are not the same as shown below. Keller (1999) also gives an alternative scoring method that is to find the average score for each subscale and the total scale instead of using sums. For each respondent, divide the total score on a given scale by the number of items in that scale. This converts the totals into a score ranging from 1 to 5 and makes it easier to compare performance on each of the subscales. He noted, “Scores are determined by summing the responses for each subscale and the total scale. Please note that the items marked reverse are stated in a negative manner. The responses have to be reversed before they can be added into the response total. That is, for these items, 5=1, 4=2, 3=3, 2=4, and 1=5.” (p. A-41). Attention consists of 8 items, 1, 4 (reverse), 10, 15, 21, 24, 26 (reverse), and 29. Confidence consists of 8 items, 3, 6 (reverse), 9, 11 (reverse), 17 (reverse), 27, 30, and 34. Relevance consists of 9 items, 2, 5, 8 (reverse), 13, 20, 22, 23, 25 (reverse), and 28. Satisfaction consists of 9 items, 7 (reverse), 12, 14, 16, 18, 19, 31 (reverse), 32, and 33.

Van Hiele Geometry Test Scoring Guide: All students’ answer sheets from VHGT were read and scored by the investigator.
All students got a score referring to a van Hiele level from the VHGT in the guidance of Usiskin’s grading system.

“For Van Hiele Geometry Test, a student was given or assigned a weighted sum score in the following manner:
1 point for meeting criterion on items 1-5 (level-I)
2 points for meeting criterion on items 6-10 (level-II)
4 points for meeting criterion on items 11-15 (level-III)
8 points for meeting criterion on items 16-20 (level-IV)
16 points for meeting criterion on items 21-25 (level-V)” (Usiskin, 1982, p.22)
The criterion was three of five correct.

**Operational Definitions:**

The following scales were used in the process of assigning student’s performance level based on their responses for the test items. The reason using these two scales was that students might get correct some items for a higher level while missing items at a lower level.

- **Classical Van Hiele level** (i.e., the level if the entire theory is considered):

<table>
<thead>
<tr>
<th>Level</th>
<th>corresponds to weighted sum</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>3</td>
<td>7</td>
</tr>
<tr>
<td>4</td>
<td>15</td>
</tr>
<tr>
<td>5</td>
<td>31</td>
</tr>
</tbody>
</table>

- **Modified Van Hiele Level** (the level if level 5 is excluded from consideration):

<table>
<thead>
<tr>
<th>Level</th>
<th>corresponds to weighted sum</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0 or 16</td>
</tr>
<tr>
<td>0</td>
<td>1 or 17</td>
</tr>
<tr>
<td>1</td>
<td>3 or 19</td>
</tr>
<tr>
<td>2</td>
<td>5 or 23</td>
</tr>
</tbody>
</table>
The assigning of levels in either the classical or modified case requires that a student’s responses satisfy Property 1 of the levels, i.e., that the student at level \( n \) satisfy the criterion not only at that level but also at all preceding levels. Thus a student who satisfies the criterion at levels 1, 2 and 5, for instance, would have a weighted sum of \( 1 + 2 + 16 \) or 19 points, would have no classical Van Hiele level, but be assigned the modified Van Hiele level 2. A student who satisfies the criterion at level 3 only would not be assigned either a classical or modified Van Hiele level. Neither of these students would be said to fit the classical Van Hiele model. (One key question regards the percentage of students that do fit the model) (Usiskin, 1982, p.25).

Analysis of Data

The data were responses from students’ answer sheets. In the process of the assessment of students’ van Hiele levels, the criterion was three out of five. First the researcher run the Independent-Samples T-Test statistical procedure with \( \alpha = 0.05 \) on the students’ pretest scores to see if there exist any differences in terms of performance and motivation between the two groups. These t-test procedures showed mean score differences between the two groups favoring the control group on both students’ performance and motivation. Then, scores from both VHGT and CIS were compared using one-way analysis of covariance (ANCOVA) with \( \alpha = 0.05 \), which is a variation of ANOVA, was used to adjust for pretest differences that exist between control and treatment groups. “For instance, suppose in an experiment that one group has a mean value on the pretest of 15 and the other group has a pretest mean of 18. ANCOVA is used to adjust the posttest scores statistically to compensate for the 3-point difference between the two groups. This adjustment results in more accurate posttest
comparisons. The pretest used for the adjustment is called the covariate” (McMillan, 2000, p.244). In other words, because of the initial differences in regard to students’ performance and motivation between two groups, ANCOVA was employed to analyze the quantitative data in the study. The pretest performance scores from the Van Hiele Geometry Test served as the covariate in the performance analysis by curricula and gender effect. Similarly, the pretest motivation scores from the Course Interest Survey served as the covariate in the motivation analysis by curricula and gender effect. ANCOVA enabled the researcher to see the results of comparisons of both VHGT and CIS scores.

Moreover, the Paired-Samples T-Test with $\alpha = 0.05$ was used to detect the mean differences between pre-and posttest scores of students in each group separately based on the Van Hiele Geometry Test and Course Interest Survey. The Paired-Samples T-Test procedure compares the means of two variables for a single group. It computes the differences between values of the two variables for each case. This also helped the researcher see the effects of each curriculum on students’ performance and motivation for each group. In addition, the researcher constructed frequency tables to get deep information about students’ van Hiele levels distributions for both groups.
CHAPTER 4

DATA ANALYSIS & RESULTS

Introduction

This chapter reports the results of analysis of data collected during the study. It provides descriptive data for dependent variables, students’ performance and motivation, and determines if significant differences exist between the treatment and control groups in regard to the research hypotheses.

The Van Hiele Geometry Test (VHGT) was employed to measure students’ performance in the geometry classes. The VHGT consists of 25 multiple-choice geometry questions sequenced according to the van Hiele levels. In other words, the first five (1 through 5) items in the test contain level-I (recognition) geometry knowledge, the second five (6 through 10) contain level-II (analysis) geometry knowledge, the third five (11 through 15) contain level-III (ordering) geometry knowledge, the fourth five (16 through 20) contain level-IV (deduction) and the fifth five (21 through 25) contain level-V (rigor) geometry knowledge.

The Course Interest Survey (CIS), used to detect students’ motivation, consists of 34 Likert-type items. Each item in the questionnaire was intended to measure one of the following motivational constructs: (a) attention,
(b) relevance, (c) confidence, and (d) satisfaction. The sum of the motivational constructs gives the overall motivation of the students in the geometry classes.

A total of 273 sixth grade mathematics students in two public middle schools in Tallahassee, Florida were involved in the study. One hundred twenty-three students were in the control group and 150 were in the treatment group. Due to student absenteeism, only the performance and motivation scores for those students who took both pre-and posttests were analyzed. In the analysis of the data, first the Independent-Samples T-Test procedure, comparing means for two groups of cases, with $\alpha = 0.05$ was used to compare the mean differences between the pretest scores of both groups based on the VHGT and CIS. Then, the analysis of covariance (ANCOVA) with $\alpha = 0.05$, a parametric procedure that has the same purpose as the Independent-Samples T -Test, was used to compare group means and decide the probability of being wrong in rejecting the null hypotheses. In addition, ANCOVA adjusted pretest differences and compared posttest results. In other words, because of the initial differences in regard to students’ performance and motivation between two groups, ANCOVA was employed to analyze the quantitative data in the study. The pretest performance scores from the geometry test served as the covariate in the performance analysis by curricula and gender effect. Likewise, the pretest motivation scores from the survey served as the covariate in the motivation analysis by curricula and gender effect. Furthermore, the Paired-Samples T-Test with $\alpha = 0.05$ was used to detect the mean differences between pre-and posttest scores of students in each group separately based on the VHGT and CIS. The Paired-Samples T-
Test procedure compares the means of two variables for a single group. It computes the differences between values of the two variables for each case. This also helped the researcher see the effects of each curriculum on students’ performance and motivation for each group. Levene’s Test with $\alpha = 0.05$ showed no violation of the equality of variance assumption in all the ANCOVA and the Independent-Samples T-Test tables used in the study. All analyses were conducted using SPSS 11.0. In this chapter, the research questions are answered first, followed by the results of the research hypotheses, and then finishes with a brief summary.

**Descriptive Data**

**The Research Questions**

Question 1. What differences exist between students who are instructed with a van Hiele theory based curriculum and students not instructed with a van Hiele theory based curriculum with reference to their performance in learning geometry?

Table 1 presents the descriptive statistics and the Paired-Samples t-test for students’ performance based on the van Hiele levels by the curricula in both the treatment and control groups. According to the Paired-Samples t-test (Table 1), the mean score differences between the pre-and posttests on the VHGT in the treatment group is statistically significant, \[ p < 0.001, \text{significant at the } \alpha/2 = 0.025 \text{ using critical value of } t \alpha/2 = -1.96 \], and the mean score differences between the pre-and posttests on the VHGT in the control group is also statistically
significant, \( p < 0.025 \), significant at the \( \alpha/2 = 0.025 \) using critical value of \( t_{\alpha/2} = -1.96 \). Based on these statistical test results, one would say that both curricula have positive effects on students’ performance in geometry.

Table 1

<table>
<thead>
<tr>
<th>Groups</th>
<th>N</th>
<th>Pretest</th>
<th>Posttest</th>
<th>Posttest***</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>M</td>
<td>SD</td>
<td>M</td>
</tr>
<tr>
<td>Treatment</td>
<td>150</td>
<td>0.69</td>
<td>0.581</td>
<td>1.05</td>
</tr>
<tr>
<td>Control</td>
<td>123</td>
<td>0.71</td>
<td>0.610</td>
<td>0.93</td>
</tr>
<tr>
<td>Total</td>
<td>273</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note. a: Evaluated at covariates appeared in the model: Pre-performance = 0.70, ***Estimated Marginal Means.** \( p < 0.001 \), significant at the \( \alpha/2 = 0.025 \) using critical value of \( t_{\alpha/2} = -1.96 \). * \( p <0.025 \), significant at the \( \alpha/2 = 0.025 \) using critical value of \( t_{\alpha/2} =-1.96 \), \( p=0.001 \).

Although Table 1 indicates that there is a gain in both groups, the gain of the treatment group is relatively higher than that of the control group, \( \text{[the mean score of the treatment group is 1.050}, \, \text{and the mean score of the control group is 0.930]} \). However, the analysis of covariance (ANCOVA) (see Table 2) shows there is no statistically significant differences on the performance of students who are instructed with a van Hiele theory based curriculum and students not instructed with a van Hiele theory based curriculum in learning geometry \( [F (1, 272) = 2.222; \, p =0.137, \, p > 0.05] \).
According to Burger & Shaughnessy (1986), the progress through the levels is dynamic, not discrete. Despite the fact that students can be assigned to a single van Hiele level, there may be students who cannot be assigned to a single van Hiele level. Gutierrez, Jaime, & Fortuny (1991) used a 100-point numerical scale to determine the van Hiele levels of students who reason between the two levels. This numerical scale is divided into five qualitative scales: “Values in interval” (0%, 15%) means “No Acquisition” of the level. “Values in the interval” (15%, 40%) means “Low Acquisition” of the level. “Values in the interval” (40%, 60%) means “Intermediate Acquisition” of the level. “Values in the interval” (60%, 85%) means “High Acquisition” of the level. Finally, “values in the interval” (85%, 100%) means “Complete Acquisition” of the level” (p.43).

The interpretation of the mean score 0.93 of the control group can be explained with the scale described above. The score 0.93 can be placed into the last interval named “Complete Acquisition” of the level. In other words, students who were in the control group completed to the previous level, level-0 (Pre-recognition), identified by
Clements & Battista (1990) and they have attained to the next level, level-I (Visualization or Recognition), described by van Hiele (1986). At level-I students recognize and identify geometric figures according to their appearance, but they do not understand the properties or rules of figures. For example, they can identify a rectangle, and they can recognize it easily because of its shape, which looks like the shape of a window or a shape of a door. On the other hand, the interpretation of the mean’ score 1.05 for the treatment group would be that students average van Hiele level falls between levels -I and -II. Using the interval scale, the .05 indicates that there is no acquisition of level -II understanding. Therefore, students in both groups demonstrated level-I geometry performance.

Another way to see differences between the control and treatment groups is to look at students’ progress from one level to another level (Table 3). For example, 20% (37.3% - 17.3%) of students in the treatment group moved to a higher Van Hiele level, while 10% (37.4% - 27.6%) of students in control group moved from level-0 to the higher levels. A larger number of students in the treatment group progressed from level-0 to level-I than in the control group. Students’ progresses from levels-0 and-I to level-II are almost the same for both groups, 11.4 % (17.4% - 6%) for the treatment group, and 12 % (20.4% - 8.1%) for the control group.
### Table 3

*Frequency Table for Students’ Performance Based on van Hiele Levels by Curricula*

<table>
<thead>
<tr>
<th>Groups</th>
<th>N</th>
<th>Level-0</th>
<th></th>
<th>Level-I</th>
<th></th>
<th>Level-II</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>n</td>
<td>%</td>
<td>n</td>
<td>%</td>
<td>n</td>
<td>%</td>
</tr>
<tr>
<td>Treatment</td>
<td>150</td>
<td>Pre-performance</td>
<td>56</td>
<td>37.3</td>
<td>85</td>
<td>56.7</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Post-performance</td>
<td>26</td>
<td>17.3</td>
<td>98</td>
<td>65.3</td>
<td>26</td>
</tr>
<tr>
<td>Control</td>
<td>123</td>
<td>Pre-performance</td>
<td>46</td>
<td>37.4</td>
<td>67</td>
<td>54.5</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Post-performance</td>
<td>34</td>
<td>27.6</td>
<td>64</td>
<td>52</td>
<td>25</td>
</tr>
</tbody>
</table>

**Note.** *n* is the number of students in selected group.

Question 2. What differences exist with respect to motivation between students instructed with a van Hiele theory based curriculum and students not instructed with a van Hiele theory based curriculum in geometry?

Table 4 presents the descriptive statistics and the Paired-Samples t-test for students’ motivation based on the CIS scores by the curricula in both the treatment and control groups, and shows that there is a gain in overall motivation of students for both groups. According to the Paired-Samples t-test (Table 4), the mean score differences in terms of motivation between the pre-and posttests on the CIS in the treatment group is statistically significant, [\( p < 0.001, \) significant at the \( \alpha/2 = 0.025 \) using critical value of \( t_{\alpha/2} = -1.960 \)], and the mean score differences as to motivation between the pre-and posttests on the CIS in the control group is also statistically significant, [\( p < 0.025, \) significant at the \( \alpha/2 = 0.025 \) using critical value of \( t_{\alpha/2} = -1.960 \)]. In other words, both curricula whether based on the van Hiele...
theory or not have strongly impacted students’ motivation in the study.

Table 4
Descriptive Statistics and the Paired-Samples T-Test for Students’ Motivation Based on the CIS Scores by Curricula

<table>
<thead>
<tr>
<th>Groups</th>
<th>N</th>
<th>Pretest M</th>
<th>SD</th>
<th>Posttest M</th>
<th>SD</th>
<th>t</th>
<th>Posttest M</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment</td>
<td>150</td>
<td>119.81</td>
<td>15.3</td>
<td>129.53</td>
<td>14.0</td>
<td>-11.738**</td>
<td>132.042^a</td>
<td>0.7</td>
</tr>
<tr>
<td>Control</td>
<td>123</td>
<td>127.48</td>
<td>17.6</td>
<td>132.32</td>
<td>16.3</td>
<td>-5.034**</td>
<td>129.257^a</td>
<td>0.8</td>
</tr>
<tr>
<td>Total</td>
<td>273</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note. a: Evaluated at covariates appeared in the model: Pre-motivation =123.26, *Estimated Marginal Means, CIS: Course Interest Survey. ** p < 0.001, significant at the α/2 = 0.025 using critical value of tα/2 = -1.960.

Table 5, however, displays the analysis of covariance (ANCOVA) for both groups with regard to students’ motivation, and is based on the Course Interest Survey. It shows a significant main effect for students’ motivation toward a van Hiele theory based curriculum was obtained, [F (1, 272) = 5.660; p = 0.018, p < 0.05]. Furthermore, Table 4 indicates that students instructed with a van Hiele theory based curriculum outscored the ones who were not instructed with a van Hiele theory based curriculum in geometry, [the mean score of the treatment group is 132.042^a, and the mean score of the control group is 129.257^a]. In other words, Table 6 shows that growth in students’ motivation from low and average levels to high in the treatment group is higher than that of the control group. For instance, a 17.3% (38% - 20.7%) change occurred with students in the treatment group, while a 6.4% (48.6% - 42.2%) change occurred with students in the control group.
(see Table 6). Table 6 was constructed with Keller’s (1999) scoring scale. According to his scale, the minimum score is 34 on the CIS, and the maximum is 170 with midpoint of 102. In this study, the researcher used levels representing “Low”, “Average” and “High” based on students’ CIS scores. “Low” means that students’ CIS scores are in the range between 34 and 101. “Average” means that students’ CIS scores are in the range between 102 and 135. “High” means that students’ CIS scores are in the range between 136 and 170.

Table 5
Summary of ANCOVA for Students’ Motivation Based on the CIS Scores by Curricula

<table>
<thead>
<tr>
<th>Sources</th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F-statistic</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pretest</td>
<td>38450.674</td>
<td>1</td>
<td>38450.674</td>
<td>437.800</td>
<td>0.0001</td>
</tr>
<tr>
<td>Group</td>
<td>497.139</td>
<td>1</td>
<td>497.139</td>
<td>5.660</td>
<td>0.018*</td>
</tr>
</tbody>
</table>

Note. $\alpha = 0.05$, *p = 0.018, *p < 0.05, CIS: Course Interest Survey.

Table 6
Frequency Table for Students’ overall Motivation Based on the CIS Scores by Curricula

<table>
<thead>
<tr>
<th>Groups</th>
<th>N</th>
<th>Low*</th>
<th>Average**</th>
<th>High***</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>%</td>
<td>n</td>
<td>%</td>
</tr>
<tr>
<td></td>
<td>n</td>
<td></td>
<td>n</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Treatment</td>
<td>150</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-motiva</td>
<td>15</td>
<td>10</td>
<td>104</td>
<td>69.3</td>
</tr>
<tr>
<td>Post-motiva</td>
<td>1</td>
<td>0.7</td>
<td>92</td>
<td>61.3</td>
</tr>
<tr>
<td>Control</td>
<td>123</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-motiva</td>
<td>12</td>
<td>9.8</td>
<td>59</td>
<td>48</td>
</tr>
<tr>
<td>Post-motiva</td>
<td>4</td>
<td>3.2</td>
<td>58</td>
<td>47.2</td>
</tr>
</tbody>
</table>

Note. * CIS scores in the range of 34 -101, ** CIS scores in the range of 102-135, *** CIS scores in the range of 136-170. CIS: Course Interest Survey, n is the number of students in the selected group.
Question 3. What differences exist in terms of performance in geometry between male and female students instructed with a van Hiele theory based curriculum?

Table 7 presents the descriptive statistics for students’ performance based on the van Hiele levels in the treatment group, and indicates that the male students’ mean score is numerically higher than that of the female students. The analysis of covariance (ANCOVA) as shown in Table 8 below, however, displays that this difference is not statistically significant as to students’ performance in geometry between male and female students instructed with a van Hiele theory based curricula, \( F (1, 149) = 2.446; p = 0.120, p > 0.05 \). While it seems that there is a gain favoring male students based on their performance in geometry, it is not statistically significant. Table 9 shows the progress of male students from level-0 to higher levels are almost equal to the progress of female students.

<table>
<thead>
<tr>
<th>Gender</th>
<th>N</th>
<th>Pretest</th>
<th>Posttest</th>
<th>Posttest*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>M</td>
<td>SD</td>
<td>M</td>
</tr>
<tr>
<td>Male</td>
<td>66</td>
<td>0.71</td>
<td>0.57</td>
<td>1.15</td>
</tr>
<tr>
<td>Female</td>
<td>84</td>
<td>0.67</td>
<td>0.58</td>
<td>0.96</td>
</tr>
<tr>
<td>Total</td>
<td>150</td>
<td>0.67</td>
<td>0.58</td>
<td>0.96</td>
</tr>
</tbody>
</table>

Note. a: Evaluated at covariates appeared in the model: Pre-performance = 0.69.
Table 8
Summary of ANCOVA for Students’ Performance Based on the van Hiele levels by Gender

<table>
<thead>
<tr>
<th>Sources</th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F-statistic</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pretest</td>
<td>7.872</td>
<td>1</td>
<td>7.872</td>
<td>18.223</td>
<td>0.0003</td>
</tr>
<tr>
<td>Gender</td>
<td>1.057</td>
<td>1</td>
<td>1.057</td>
<td>2.446</td>
<td>0.120*</td>
</tr>
</tbody>
</table>

*Note. α = 0.05, *p = 0.120

Table 9
Frequency Table for Students’ Performance Based on the van Hiele Levels by Gender

<table>
<thead>
<tr>
<th>Groups</th>
<th>N</th>
<th>Level-0</th>
<th>Level-I</th>
<th>Level-II</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>%</td>
<td>n</td>
<td>%</td>
</tr>
<tr>
<td>Male</td>
<td>66</td>
<td>34.8</td>
<td>39</td>
<td>59.1</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>15.2</td>
<td>41</td>
<td>62.1</td>
</tr>
<tr>
<td>Female</td>
<td>84</td>
<td>39.3</td>
<td>46</td>
<td>54.8</td>
</tr>
<tr>
<td></td>
<td>16</td>
<td>19</td>
<td>57</td>
<td>67.9</td>
</tr>
</tbody>
</table>

*Note. n is the number of students in the selected group.

Question 4. What differences exist with regard to motivation between male and female students instructed with a van Hiele theory based curriculum?

Table 10 presents the descriptive statistics for students’ motivation based on the CIS Scores in the treatment group, and shows that the males’ mean score (130.575) is numerically higher than that of the females (128.715). Table 11 presents the analysis of covariance (ANCOVA) for the treatment group with regard to motivation in geometry, and indicates that gender does not have an effect on students’ motivation in learning geometry, [F (1,149) = 1.549; p = 0.215, p>0.05]. Table 12 supports this
result. It shows that similar motivational growth happened to both male and female students in all three categories.

Table 10
Descriptive Statistics for Students’ overall Motivation based on the CIS Scores by Gender

<table>
<thead>
<tr>
<th>Gender</th>
<th>N</th>
<th>Pretest M</th>
<th>SD</th>
<th>Posttest M</th>
<th>SD</th>
<th>Posttest* M</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>66</td>
<td>121.14</td>
<td>15.96</td>
<td>131.50</td>
<td>14.64</td>
<td>130.575a</td>
<td>1.1</td>
</tr>
<tr>
<td>Female</td>
<td>84</td>
<td>118.76</td>
<td>14.85</td>
<td>127.99</td>
<td>13.43</td>
<td>128.715a</td>
<td>0.9</td>
</tr>
</tbody>
</table>

Note. a: Evaluated at covariates appeared in the model: Pre-motivation =119.81, CIS: Course Interest Survey

Table 11
Summary of ANCOVA for Students’ overall Motivation Based on the CIS Scores by Gender

<table>
<thead>
<tr>
<th>Sources</th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F-statistic</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pretest</td>
<td>16869.864</td>
<td>1</td>
<td>16869.864</td>
<td>205.532</td>
<td>0.0001</td>
</tr>
<tr>
<td>Gender</td>
<td>127.158</td>
<td>1</td>
<td>127.158</td>
<td>1.549</td>
<td>0.215*</td>
</tr>
</tbody>
</table>

Note. α = 0.05, * p = 0.215, CIS: Course Interest Survey.

Table 12
Frequency Table for Students’ overall Motivation Based on the CIS Scores by Gender

<table>
<thead>
<tr>
<th>Gender</th>
<th>N</th>
<th>Low*</th>
<th>Average**</th>
<th>High***</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>%</td>
<td>n</td>
<td>%</td>
</tr>
<tr>
<td>Male</td>
<td>66 Pre-motiva</td>
<td>6</td>
<td>9</td>
<td>44</td>
</tr>
<tr>
<td></td>
<td>Post-motiva</td>
<td>0</td>
<td>0</td>
<td>39</td>
</tr>
<tr>
<td>Female</td>
<td>84 Pre-motiva</td>
<td>9</td>
<td>10.7</td>
<td>58</td>
</tr>
<tr>
<td></td>
<td>Post-motiv</td>
<td>1</td>
<td>1.1</td>
<td>53</td>
</tr>
</tbody>
</table>

Note. * CIS scores in the range of 34 –101, ** CIS scores in the range of 102–135, *** CIS scores in the range of 136–170, CIS: Course Interest Survey, n is the number of students in the selected group.
Analysis of the Hypotheses

Based on the four research questions there are four research hypotheses. The first one is relevant to students’ performance in geometry. The second one is about the students’ overall motivation. The third one is regarding gender impact on students’ performance, and the last one is about effect of gender with regard to students’ motivation. The researcher set the $\alpha$ level as 0.05 for the Independent-Samples t-test and 0.05 for the analysis of covariance to detect the mean score differences between the treatment and control groups.

In the analysis of these hypotheses, the researcher first ran the Independent-Samples t-test in order to detect the initial differences in terms of students’ performance and motivation between the pretest scores of students in both the treatment and control groups. For the pretests, the Independent-Samples t-test results showed that there always exist some mean score differences with reference to students’ performance and motivation between the two groups favoring each one based on cases. Therefore, in order to adjust these pretest differences, the analysis of covariance (ANCOVA), which “is used to adjust for pretest differences that may exist between two or more groups” (McMillan, 2000, p.244) was chosen to examine these hypotheses.

$H_0 - 1$: There is no difference on geometry performance between students instructed with a van Hiele theory based curriculum and
students not instructed with a van Hiele theory based curriculum.

$H_a - 1$: Students instructed with a van Hiele theory based curriculum perform better than students not instructed with a van Hiele theory based curriculum in learning geometry.

To test these hypotheses, the Independent-Samples t-test with $\alpha = 0.05$ for the Pre-Van Hiele Geometry Test indicated that the mean score (0.71) of students in the control group (using not a van Hiele theory based curriculum) was higher than that (0.69) of students in the treatment group (using a van Hiele theory based curriculum). This result means that there was an initial group differences. On the other hand, the Independent-Samples t-test for the posttest scores showed the visa-versa. In the posttest, the mean score (1.05) of students in the treatment group was numerically higher than that (0.93) of students in the control group. The analysis of covariance adjusted the initial group differences and posited that the mean difference in terms of students’ performance between the two groups was not statistically significant, $[F (1, 272) = 2.222; p = .137, p > 0.05]$. Therefore, this result supports the null hypothesis ($H_0 - 1$: There is no difference in geometry performance between students instructed with a van Hiele theory based curriculum and students not instructed with a van Hiele theory based curriculum), and it rejects $H_a - 1$ (students instructed with a van Hiele theory based curriculum perform better students not instructed with a van Hiele theory based curriculum in learning geometry).
$H_0 - 2$: There is no difference in respect to motivation in geometry between students instructed with a van Hiele theory based curriculum and students not instructed with a van Hiele theory based curriculum.

$H_a - 2$: Students instructed with a van Hiele theory based curriculum show stronger motivational performance than students not instructed with a van Hiele theory based curriculum in learning geometry.

The Independent-Samples t-test for both groups on the Pre-CIS in the students’ motivation showed that there was initial differences exist between these two groups based on their overall motivations. Therefore, the analysis of covariance was employed to examine these hypotheses. It indicated that there was a statistically significant mean score differences in terms of students’ motivation between the treatment and control groups, $[F (1, 272) = 5.660; p = 0.018, p < 0.05]$. Moreover, the mean score (132.042) of students in the treatment group was numerically higher than that (129.257) of students in the control group. This result rejects the null hypothesis and accepts the alternate research hypothesis.

$H_0 - 3$: There is no gender difference as to performance in geometry between male and female students instructed with a van Hiele theory based curriculum.

$H_a - 3$: The mean score of male students with respect to performance is higher than that of female
students instructed with a van Hiele theory based curriculum.

The Independent-Samples t-test for pre-van Hiele geometry test scores in the treatment group displayed that there was initial mean score differences on performance between male and female students favoring male students. Because of the initial differences on performance, the analysis of covariance was employed to compare the posttest scores on the Van Hiele Geometry Test. It revealed that the mean score differences on performance between male and female students were not statistically significant, \( F (1, 149) = 2.446; p = 0.120, p > 0.05 \). This result supports the null hypothesis, and rejects the alternate research hypothesis.

\[ H_0 - 4: \text{There is no gender difference with regard to motivation in geometry between male and female students instructed with a van Hiele theory based curriculum.} \]

\[ H_a - 4: \text{The mean score of male students as to motivation is higher than that of female students instructed with a van Hiele theory based curriculum.} \]

The Independent-Samples t-test for the Pre-CIS scores in the treatment group revealed that there was an existing mean score differences on students’ motivation in geometry classes between male and female students exposed to an instruction using the van Hiele based curricula favoring male students. Because of the initial differences on students’ motivation, the analysis of covariance was used to test the research hypotheses. It showed that there was
no statistically significant gender effect on students’ overall motivation in the treatment group, \( F(1,149) = 1.549; p = 0.215, p > 0.05 \). In addition, although Table 10 shows that the mean score of male students seems to be higher than that of female students, the mean score differences in students’ motivation was not statistically significant. This result rejects the alternate hypothesis, and accepts the null hypothesis. In other words, gender has no effect on the motivation of the students instructed with the van Hiele based curricula.

Summary

The Paired-Samples t-test for the treatment group showed that the mean score differences between the pre- and posts on The Van Hiele Geometry Test was statistically significant, and it was also true for the control group, too. In other words, both curricula had positive influence on students’ performance in geometry. However, according to results of the analysis of covariance, the mean score differences of students with respect to performance between the treatment and control groups were not statistically significant on The Van Hiele Geometry Test.

Likewise, the Paired-Samples t-test for the treatment group revealed that the mean score differences between the pre- and posts on the Course Interest Survey as to students’ motivation was statistically significant, and it was also valid for the control group, too. On the other hand, the analysis of covariance demonstrated that the mean score differences of students in regard to motivation between the treatment and control groups was statistically significant favoring the ones instructed with the van Hiele
Theory based curricula in geometry at the sixth grade level.

Gender had no effect on both students’ performance and motivation in geometry learning in the treatment group, \( F (1, 149) = 2.446; p = 0.120, p > 0.05 \) and \( F (1, 149) = 1.549; p = 0.215, p > 0.05 \), respectively.

Briefly, the ANCOVA results indicated no statistical difference in students’ performance by the curricula. The ANCOVA indicated a statistically significant difference in students’ motivation toward the van Hiele Theory based curricula. However, no statistical difference was indicated by gender in regard to students’ performance and motivation.
CHAPTER 5
DISCUSSIONS, CONCLUSIONS & RECOMMENDATIONS

Introduction

This chapter consists of the following parts: a discussion of the results, limitations of the study, conclusions, implications, and recommendations. In discussing the results, an examination of students’ overall van Hiele levels compared and contrasted with previous research findings from the literature will be provided. Following the results, there will be an analysis of both students’ performance and motivation, and finishing the discussion part with the analysis of the gender effect. Then, the researcher will briefly express the conclusions of the study, refer to the limitations, discuss implications of the study, and make some recommendations for students, teachers and future research.

Results

The results of the study could give readers a sense of understanding of the effect of the curricula prepared based on the van Hiele theory on students’ performance and motivation in learning geometry at sixth grade levels.
**Students’ overall van Hiele Levels**

The study indicated that no one performed above level-II (analysis) at the sixth grade level. Mostly students’ van Hiele geometry levels were levels-0 (pre-recognition) and -I (visualization). This result is in accordance with the findings of Burger & Shaughnessy (1986), Crowley (1987), and Fuys et al. (1988) who found that mostly level-I reasoning took place in grades K-8. This supports the idea that most younger students and many adults in the United States reason at levels-I (visualization) and -II (analysis) of the van Hiele theory (Usiskin, 1982 & 2002; Hoffer, 1986). One would expect a greater performance from these students in both the treatment and control groups, because the curricula used in both groups contain levels-0 (pre-recognition), -I (visualization), -II (analysis) and -III (ordering) geometry knowledge. Nonetheless, students taking the geometry classes the intended curricula were directed level-III geometry knowledge at the end of the geometry instruction, which is an implicit expectation of curricula from the students.

**Students’ Geometry Performance**

The first question of the study was concerning if there exists any differences with reference to geometry performance between students instructed with a van Hiele theory based curricula and students instructed with a conventional curriculum. The Paired-Samples t-test regarding students’ performance for both the treatment and control groups indicated that there was a gain for both groups. The growth of students in the treatment group between the pre-and post Van Hiele Geometry Test scores was
statistically significant. Similarly, the mean score differences of the students in the control group was also statistically significant. Therefore, one would say that both curricula, whether based on the van Hiele theory or not, have positive impacts on students’ performance in geometry. But, the gain of the students in the treatment group was numerically higher than that of their counterparts in the control group. Based on the ANCOVA results, the mean score differences of the students’ performance between the two groups, however, was not statistically significant. This means that students exposed to a conventional curriculum for five weeks of instruction in the sixth grade on The Van Hiele Geometry Test level equaled the performance of the students exposed to the instruction using a van Hiele Theory based curricula.

The National Council of Teachers of Mathematics (NCTM) (1989) recommends the use of new styles and approaches in teaching and learning in mathematics. These new styles and approaches may help students develop mathematical learning. Moreover, researches have documented that the standard-based curricula (e.g., Connected Mathematics Project, MATH Thematics, University of Chicago School Mathematics Project, Core-Plus Mathematics Project, and Everyday Mathematics) more positively affected students’ learning of mathematics than the traditional curricula (c.f., Fuson, Carroll, & Drueck, 2000; Huntley, Rasmussen, Villarubi, & Fey, 2000; Thompson & Senk, 2001; Carroll & Isaac, 2003; Reys, Reys, Lapan, Holliday, & Wasman, 2003; Senk & Thompson, 2003).

In this study, teachers in the treatment group implemented the van Hiele theory based materials for five
weeks. Although the implementation of these materials showed positive impacts on students’ learning to some extent, these impacts could not reach the expected point. This is in contrast with the argument stating that the van Hiele theory based curriculum may be more helpful than the traditional one (e.g., Crowley, 1987). In other words, the finding of the study related to students’ geometry performance did not support Crowley’s claim. It is obvious that one study does not suffice to observe and examine the effects of the van Hiele theory based curricula. In this area more studies are needed. In the study, the two teachers who instructed the students in the treatment group were knowledgeable, but not at an expertise level with regard to the van Hiele theory and its philosophies. According to Swafford, Jones, & Thornton (1997), an intervention program consisting of a content course in geometry and a research seminar presenting the van Hiele theory and its philosophies had significant effects on the middle grade teachers who claimed that knowing the van Hiele theory and its philosophies positively changed their perception of teaching geometry and their approaches to their students in the classrooms. In addition, Mayberry (1983) and Fuys, Geddes, & Tischler (1988) stated that content knowledge in geometry among pre-service and in-service middle school teachers is not adequate. According to Chappell (2003) “Individuals without sufficient backgrounds in mathematics or mathematics pedagogy are being placed in middle school mathematics classrooms to teach” (p.294).

The finding of the study regarding performance does not line up with the argument of Usiskin (1982) who said
that if students were supported with a systematic geometry instruction, they could have greater geometry knowledge than other students. Authors of the two textbooks used in the treatment group, expressed that they wrote these books based on the van Hiele levels that are hierarchical and continual. One would expect a relatively stronger impact from these materials on students’ learning in geometry because the curriculum materials (e.g., textbooks) profoundly affect teachers and guide the instructions in the mathematics classes (e.g., Driscoll, 1980; Fennema, Carpenter, & Peterson, 1989; Reys et al., 2003).

The finding of this current study, on the other hand, is in accordance with the reports of Reys et al. (2003) who conducted a research that compared the achievement of eighth grade students using NSF-funded Standards-based middle grade mathematics curriculum materials (MATH Thematics or Connected Mathematics Project) with students using traditional textbooks for at least a two year period from 1997 through 1999. In the study, “geometry and spatial sense” was one of the six content strands; Number Sense; geometry and Spatial Sense; Data Analysis, Probability, and Statistics; Algebra; mathematical Systems; and Discrete Mathematics. Their study showed that the mean’ score (60.94) of students using the Connected Mathematics Project (SB3) in terms of achievement on geometry and spatial sense was numerically higher than the mean score (57.27) of students not using same curriculum materials at the eighth grade level. This achievement difference, however, was not statistically significant (p.87). They stated, “students using the NSF Standards-based curriculum (SB3 using the CMP materials) had significantly higher scores than nonusers
(C3 not using the CMP materials) on two of the six content
Standard scales: data analysis, probability, and
statistics; and algebra” (Reys et al., 2003, p.86).

Reys et al. (2003) resolved that students using the
NSF funded Standards-based curriculum (the Connected
Mathematics Project or MATH Thematics) materials equally
performed or showed greater performance on the mandated
state mathematics achievement test than students who used
other traditional curriculum materials in middle grades for
at least two years.

Although this current study was not done with eight
graders, one of the van Hiele theory based curricula was
“Shapes and Designs” for sixth graders from the Connected
Mathematics Project materials. The result of the study as
to performance on learning geometry is consistent with
these researchers finding. However, the study of Reys et
al. (2003) pointed out that students (SB1 and SB2) using
MATH Thematics curriculum materials, NSF- funded
curriculum, outscored their counterparts using traditional
textbooks in all the six content strands. In other words,
in particular students (SB1 and SB2) using MATH Thematics
curriculum materials displayed statistically significant
performance on the mandated state mathematics achievement
test than nonusers in geometry and spatial sense.

In light of the effects of the standards-based
curricula on students’ learning, one would expect that
students instructed with a van Hiele theory based curricula
may have shown stronger learning performance in geometry
than their counterparts instructed with a traditional one.
Indeed, in this study both the van Hiele theory based
curricula and the conventional one made equally positive
impacts on students’ learning of geometry. When interpreting the students’ test scores representing an overall low performance with respect to the objectives specified in the curriculum materials, one should take into account the fact that the teaching and learning process can be affected from some other factors (named confounding variables), such as classroom settings, instructions, parents’ support, teachers’ help, peers’ support, students’ interests, learning styles, cognitive competences, fear of punishment and so forth (e.g., Usiskin, 1982; Burger & Shaughnessy, 1986; Stipek, 1998; Wentzel, 1998; Reys et al., 2003). In practice, it is difficult to control one of these variables in order to measure precisely the impact of the curricula on students’ performance in learning geometry. Therefore, the researcher was not able to control them under the circumstances of the study.

According to Berliner (1989), “The parents who know how to deal with schools will seek ways to help their children. These will be people who were successful school attendees, generally middle-class parents” (p.336). Students who were involved in the study were from low socio-economic income families. In addition, Eccles & Midgley (1989) claimed, “many young adolescents experience decrease in teacher trust of students, opportunities for student autonomy, teachers’ sense of efficacy, and continues, close, personalized contact between teachers and students and between students and their peers” (p.140). Moreover, Weinstein (1989) said, “important relationships were found between classroom environmental attributes and learning outcomes. Children’s perceptions of classroom
climate became important as a source of environmental description” (p.192).

In short, according to Usiskin (1982), Mayberry, (1983), Burger & Shaughnessy (1986), Fuys et al. (1988), and Geddes & Fortunato (1993), the quality of instruction is one of the greatest influences on students’ performance in mathematics classes. And the students’ progress from one level to the next one also depends on the quality of instruction more than other factors, such as biological age or maturation, environment, parents’ support, peers’ support and so forth (e.g., Crowley, 1987). The curriculum materials (e.g., textbooks) deeply influence teachers and guide the instructions in the mathematics classes (e.g., Driscoll, 1980; Reys et al., 2003). In addition, another factor behind students’ low performance in the study might be teachers’ geometry knowledge. Mayberry (1983) and Fuys et al. (1988) argued that content knowledge in geometry among pre-service and in-service middle school teachers is insufficient.

Students’ Motivation

The second question of this study was pertinent to whether there exist any differences in terms of motivation between students instructed with a van Hiele theory based curricula and students not instructed with a van Hiele theory based curricula. The Paired-Samples t-test regarding students’ motivation for both the treatment and control groups showed that there was a gain in motivation by the students for both groups. The mean score differences of the students in the treatment group between the pre-and posttests on the Curse Interest Survey was statistically
significant. Likewise, the mean score differences of the students in the control group between the pre-and posts on the Curse Interest Survey was also statistically significant. Based on these results, one would claim that both curricula used in the study have positive effects on students’ motivation in geometry. However, the analysis of covariance (ANCOVA) on the Course Interest Survey revealed that a significant main impact for students’ motivation toward a van Hiele theory based curricula was obtained. In other words, students exposed to a van Hiele theory based curricula showed a greater motivational performance level in learning geometry in the sixth grade than the ones exposed to the conventional one.

The study demonstrated that there was a gain with reference to students’ performance on the geometry test for both the treatment and control groups. In other words, there was an increase between pretest scores and posttest scores of the students in both groups in the geometry classes. This may indicate a positive tendency in students’ motivation toward the geometry classes. Furthermore, this finding is supported with the result of the second question in the study, but it is not aligned with the reports of research (e.g., Eccles & Midlegy, 1989; Gottfried, Fleming, & Gotfried, 2001) claiming that there is a decline in students’ motivation toward mathematics courses.

Many internal and external factors, such as feeling valued, perception of cognitive competence, benefits and threats from peers, teachers, perception of parents’ support, environment, task difficulty, real-life activities, gender, instruction, perception of success, fear of punishment, and so forth seem to play prominent
roles in students’ motivation in mathematics classrooms (e.g., Reeve, 1986; Berliner, 1989; Driscoll, 1994; Meyer, Turner, & Spencer, 1997; Wentzel, 1997/1998; Stipek, 1998; Rogers, Galloway, Armstrong & Leo, 1998; Alderman et al., 1999; Middleton, 1999; Gottfried et al., 2001). In the study, the statistically significant motivational gain in the treatment group may be attributable to the curricula used in the study. And it might also be attributable to the other variables mentioned above. The researcher was unable control the influence of these confounding variables on students’ motivation in learning geometry. In fact, it is difficult to control these variables to obtain the pure impact of the curricula used in this study.

According to Middleton & Spanias (1999), students’ perceptions of success in mathematics had a great impact in forming their motivational attitudes. They also said that teacher actions and attitudes developed earlier and highly stabilized overtime affect students’ motivation toward mathematics. Stipek (1998) highlighted the importance of the teachers’ cares about students’ motivation and performance. She argued that the nature of the instruction and the given task strongly impact students’ motivation. Clear and meaningful tasks, active participation and level of difficulty are factors that facilitate learning. Middleton & Spanias (1999) corroborate this idea when they say that carefully structured instructional design has a great influence on achievement in mathematics. In addition, curricula have a strong effect on instruction and guide the teachers (e.g., Driscoll, 1994).

According to the study of Middleton (1985), teachers believed that real-life examples or activities were major
motivating factors in a mathematics classroom. He added that it seems that using real-life applications, group practices, hands-on activities, and other strategies played important roles in students' motivation. Furthermore, he reasoned out, "in general the better teachers were at anticipating the motivational structures of their students, the better they were at providing an environment that facilitated the development of intrinsic motivation" (p.349). This shows that environment is essential to students' motivation (Stipek, 1998).

Wentzel (1998) overall concluded that parents, teachers, and peers appear to play relatively independent roles in children's lives, and the impacts of having multiple sources of support on motivational and academic outcomes were primarily additive rather than compensatory. This is aligned with the claim of Stipek (1998) who maintained that teachers have great opportunities to affect students' motivation to accomplish in school. Parents are influential, but teachers are more influential on students' motivation than the parents because teachers have more control over most aspects of instruction and the social climate of the classroom. Hence, they can easily enhance their students' motivation in mathematics (Stipek, 1998). Moreover, she claimed that “students' motivation is also affected by the social context—for example, whether students feel valued as human beings, are supported in their learning efforts by the teacher and their peers, and are allowed to make mistakes without being embarrassed” (p.16).

Wentzel (1997) pointed out that students who felt supported and valued by their teachers were willing to
engage in classroom activities and highly motivated to be successful in the mathematics classes.

According to Stipek (1998) and Middleton & Spanias (1999), carefully structured instructional design including clear and meaningful task activities and level of difficulty had a great impact on students’ achievement and motivation in mathematics. Likewise, Ryan & Pintrich (1997) and Dev (1998) stated that there was a positive correlation between students’ achievement and motivation in learning mathematics.

Briefly, research has documented that there were some vital factors, such as environment, perception of teachers’ care parents’ support, peers’ help, perception of cognitive competence, feeling valued, task difficulty, hands-on activities or real-life activities, perception of success, fear of punishment, and so forth appear to play important roles on students’ motivation in learning mathematics (i.e., Reeve, 1986; Driscoll, 1994; Meyer, Turner, & Spencer, 1997; Wenzel, 1998; Stipek, 1988; Middleton, 1999; Gottfried et al., 2001). Although each one of these variables has an impact on students’ motivation in learning geometry, the instruction strongly influenced by the curricula has more effect on students’ performance and motivation in the mathematics classes (e.g., Stipek, 1988; Fennema, Carpenter, & Peterson, 1989; Driscoll, 1994; Wentzel, 1995; Middleton & Spanias, 1999; Reys et al., 2003).

Despite the fact that van Hiele theory based curricula made a significant impact on students’ overall motivation in learning geometry at the sixth grade level, it did not make significant effects on students’ performance. This
result does not line up with the statements of Ryan & Pintrich (1997) and Dev (1998) who expressed that there is a positive correlation between students’ performance and students’ motivation in mathematics.

**Gender in terms of Performance and Motivation**

The third and fourth questions of the study were about gender with respect to performance and motivation of the sixth grade students who were instructed with a van Hiele theory based curricula. Although research has shown that there is a difference in terms of performance between male and female students in many areas of mathematics (e.g., Armstrong, 1981; Fennema & Carpenter, 1981; Jones, 1989; Smith & Walker, 1988), in recent years a considerable decrease can be seen in the gender gap between male and female students in many areas, but not all subject areas (e.g., Friedman, 1994; Lynne & Hyde, 1989; Fennema & Hart, 1994). The research findings were also varied on this issue. Some findings argue that there is a difference in terms of performance between boys and girls in mathematics at the middle school level, but others did not. In this current study, the data revealed that gender did not have an effect on students’ learning of geometry with regard to performance and motivation. In other words, male and female students instructed with a van Hiele theory based curricula showed the similar performance and motivation level in learning geometry. This finding is not in contrast with the finding of Lapan, Reys, Barnes, and Reys (1998) who claimed that no gender differences were found in traditional mathematics achievement at the sixth grade level. Moreover, the findings of Armstrong (1981) and Fennema & Sherman
(1978) support this result. Armstrong (1981) claimed that the California Assessment Program indicated no difference in the achievement of boys and girls in the sixth grade level in the skills of geometry application. Fennema & Sherman (1978) found that there was no sex-related difference in terms of motivation between male and female students in mathematics. They also added that there was no significant sex-related difference in spatial visualization. However, according to Fennema & Carpenter (1981), girls at the middle school level (13-year-old students involved in the study) showed poor performance on geometry and measurement exercises involving spatial visualization skills.

**Limitations of the Study**

The findings of the study were limited in the type of research, the topic, time constraints, and grade level. First, the study was a quasi-experimental study with students not randomly selected. Indeed, conducting a pure (randomness) experimental study is difficult due to some reasons, including gaining access to schools and identifying appropriate comparison groups. The researcher had to conduct a quasi-experimental study rather than true experimental study because of the availability of groups. The nature of the quasi-experimental study restricts the generalizability of the study. The findings can be applied to similar groups (e.g., Cresswell, 1994; Johnson & Christensen, 2000; McMillan, 2000).

A student can perform better in one area; yet not show the same performance level in other areas (Fuys et al., 1988; Burger & Shaughnessy, 1986). Therefore, the geometry
The topics investigated in the study were polygons and tessellations. The findings of the study could not be applied to all geometry topics.

It was five weeks of treatment. I think that the duration of time given by the schools for the topics to be covered was not enough. Time constraints also pushed the teachers to limit their instructions and limit the students’ interactions with each other in the classes. Certainly, students needed more time to think about the subject matter, work on the tasks assigned by the teacher, and to share their ideas in the class.

There were also four mathematics teachers involved in the study. The teachers being in different age groups and having different levels of experience may have limited the findings of the study. Romberg & Shafer (2003) expressed that the instructional experiences affect students’ learning mathematics with understanding (p.245).

In addition, the vast majority of the students were from low socio-economic income families. Therefore, these findings should not be assumed to generalize to students from other socio-economic income families.

Conclusion

Finally, the study reached several conclusions based on the quantitative data. Firstly, most of the students’ geometry performances on The Van Hiele Geometry Test in both the treatment and control groups were levels-0 (pre-recognition) and -I (visualization). No one performed above level-II (analysis) among the students involved in the study. Secondly, although students using a van Hiele theory based curricula showed a statistically significant
motivational level in learning geometry at the sixth grade level, they did not show a statistically significant performance on the geometry test. In other words, students instructed with a van Hiele theory based curricula on the geometry test for five weeks at the sixth grade level equaled the performance, and exceeded the overall motivation of the students instructed with a traditional curriculum material. Thirdly, the study concluded that gender had no impact on students’ performance and motivation in learning geometry at the sixth grade level.

Implications of the Study

There were many factors, such as classroom environment, curriculum, instructional style, perception of success, teachers’ attitude, support of parents, teachers, and peers, learning style, and so forth, playing prominent roles in the students’ learning of geometry (e.g., Usiskin, 1982; Fuys, Geddes, & Tischeler, 1988; Wentzel, 1998; Reys, Reys, Lapan, Holliday, & Wasman, 2003). Certainly, curriculum was one of the major ones facilitating learning because of the fact that it shaped the instruction and guided teachers who could help students overcome their difficulties in learning mathematics (e.g., Messick & Reynold, 1992; Burger & Shaughnessy, 1986; Reys et al., 2003). In addition, the National Council of Teachers of Mathematics (1989) highlighted the importance of using new educational theories and approaches in teaching and learning mathematics.

The current study showed that a van Hiele theory based curricula in comparison to a traditional one had a positive impact on students’ overall motivation in learning geometry
at the sixth grade level. It suggests that if mathematics teachers pay attention to a van Hiele theory based curricula, and prepare their lessons under the guidance of this theory, they could be more successful in motivating their students toward their classes. They could easily understand the difficulties of their students because of the fact that the van Hiele theory has its own well-defined levels, visualization, analysis, order, deduction, and rigor that are in a hierarchical order and the progress is from one level to the next.

The study demonstrated that students exposed to instruction using the van Hiele theory based curricula showed significant growth in their motivation in the geometry classes. These students, on the other hand, did not show a significant increase in their performance on the geometry test given at the end of the instruction. However, according to Dev (1998) and Ryan & Pintrich (1997), there is a positive correlation between students’ performance and motivation in mathematics. Therefore, one would say that if there is an increase in students’ motivation in the class, there can be a increase in students’ performance, because of the fact that well-motivated students are willing to learn, spend more time on studying, do assignments regularly, and participate in the class discussion, which results in a great performance in the mathematics classroom (e.g., Ethignton, 1992; Stipek, 1998). Moreover, many researchers found that most of the students in both middle and high schools lacked motivation in geometry classes (e.g., Usiskin, 1982; Gottfried et al., 2001). Therefore, the van Hiele curricula may help students enhance their motivation in learning geometry.
The third and fourth findings of the study suggested that gender did not have an effect on students’ learning in regard to performance and motivation in geometry class. Some research indicated that male students perceived mathematics as a male domain, and there was a difference between boys and girls as to students’ performance and motivation in learning geometry-favoring boys (e.g., Fennema & Carpenter, 1981; Ethington, 1992). This current study revealed that gender’s influence in the treatment group was equal on students’ performance and motivation in learning geometry. In other words, the findings of the study may remove the bias about gender’s impact on students’ performance and motivation between boys and girls where boys were favored in the students’ learning of geometry.

In summary, significant curricular implications from the investigations are stated as follows:

1. The Van Hiele theory based curricula may increase students’ motivation toward a geometry class at the sixth grade level.

2. Both the van Hiele based curricula and non-van Hiele based curricula may show similar impact on students’ performance in geometry.

3. No significant differences were found between male and female students using a van Hiele theory based curriculum in regard to performance and motivation in the geometry classes. The van Hiele based curricula might be one of the factors that may have helped female students to overcome the perception of mathematics as a male domain.
4. This current study underlined the importance of recommendations made by NCTM stating that new educational theories and strategies be implemented in mathematics classrooms.

**Recommendations for the Classroom Teachers and Students**

Crowley (1987) expressed that there is a need for the classroom teachers and researchers to develop van Hiele theory based materials and implement those materials in the mathematics classrooms. The current study was about the implementation of curricula designed on the van Hiele theory and its effectiveness in teaching and learning geometry. The findings of the study were responses to concerns of Usiskin (1982) and Crowley (1987). The study revealed that the instruction using the van Hiele theory based curricula had more influence on students’ motivation in learning geometry at the sixth grade level than the ones not using the same curricula.

The study has some recommendations for mathematics teachers based on its findings:

1. They should give more attention to the van Hiele theory based curricula in their teaching because it may positively change their students’ attitudes toward the geometry classes.

2. They should engage in professional development that focuses on the van Hiele levels and their characteristics. They can benefit from the structure and properties of the van Hiele levels in determining their objectives and in preparing their lesson plans. It would be prudent if they
consider the fact that the middle school students’ reasoning can reach level-II at most, which is one of the findings of this study depicting a concurrence with the previous research findings (e.g., Burger & Shaughnessy, 1986).

3. They should give equal opportunity to boys and girls in the class.

Some recommendations for the students:

1. They can study geometry from both curriculum materials because both curriculum materials have their own merits and impacts on students’ performance in learning geometry.

2. They can give more attention to the van Hiele theory based curricula. It may positively affect their motivation toward the geometry classes.

3. Although research has shown that boys perform better than girls in mathematics, both boys and girls exposed to an instruction using van Hiele theory based curricula in the study equally performed. Therefore, if girls study geometry from the van Hiele theory based curricula, they may overcome the idea stating that mathematics is a male domain.

Recommendations for the Future Research

The current study investigated the effectiveness of the van Hiele theory based curricula in regard to students’ performance and motivation in learning geometry at the sixth grade level. This study was limited by the topics examined and time spent. I examined polygons and
tessellations for five weeks. I think that the curricula play prominent roles in the teaching and learning of geometry and in other mathematics topics because it has an enormous impact on instruction, and guides the teachers and the students (e.g., Driscoll, 1980; Reys et al., 2003). I conducted my research with sixth graders; if I had a chance I would go further in this area and also work with other students in both middle and high schools. Working with middle and high school students coming from middle-class or high–class families might give profound information about the effectiveness of the van Hiele theory based curriculum on students’ motivation and performance in geometry. In addition, study topics can be extended to the other geometry subjects, such as lines, line angle relations, circle, and volume, in order to have an opportunity to examine and compare the effectiveness of a van Hiele based curriculum with that of a conventional one.

Moreover, more quantitative studies are needed to investigate the effectiveness of the van Hiele theory based curricula in regard to students’ performance and motivation at the sixth grade and different grade levels. Likewise, more qualitative studies are needed to examine why the van Hiele theory based curricula has more impacts on students’ motivation, and why it has no significant influence on students’ performance in learning geometry. In addition, studies are needed to investigate the role of gender in learning geometry in different grade levels.

The effects of other independent variables on students’ learning of geometry, such as classroom environment, learning style, parental support, teachers’ caring, peers’ help, instructional style, and so forth may
be investigated and their interactions would be examined in order to get deep information and help students to enhance their knowledge of geometry.
APPENDIX A

Test Instruments (The Van Hiele Geometry Test & The Course Interest Survey)
1. Which of these are squares?
   (A) K only
   (B) L only
   (C) M only
   (D) L and M only
   (E) All are squares.

2. Which of these are triangles?
   (A) None of these are triangles.
   (B) V only
   (C) W only
   (D) W and X only
   (E) V and W only

3. Which of these are rectangles?
   (A) S only
   (B) T only
   (C) S and T only
   (D) S and U only
   (E) All are rectangles.
4. Which of these are squares?

(a) None of these are squares.
(b) G only
(c) F and G only
(d) G and I only
(e) All are squares.

5. Which of these are parallelograms?

(a) J only
(b) L only
(c) J and H only
(d) None of these are parallelograms.
(e) All are parallelograms.

6. PQRS is a square.

Which relationship is true in all squares?

(a) PR and QS have the same length.
(b) QS and PR are perpendicular.
(c) QS and QR are perpendicular.
(d) RS and QS have the same length.
(e) Angle Q is larger than angle R.
7. In a rectangle GHJK, GJ and HK are the diagonals.

Which of (A)-(D) is not true in every rectangle?
(A) There are four right angles.
(B) There are four sides.
(C) The diagonals have the same length.
(D) The opposite sides have the same length.
(E) All of (A)-(D) are true in every rectangle.

8. A rhombus is a 4-sided figure with all sides of the same length.
Here are three examples.

Which of (A)-(D) is not true in every rhombus?
(A) The two diagonals have the same length.
(B) Each diagonal bisects two angles of the rhombus.
(C) The two diagonals are perpendicular.
(D) The opposite angles have the same measure.
(E) All of (A)-(D) are true in every rhombus.
9. An isosceles triangle is a triangle with two sides of equal length. Here are three examples:

Which of (A)-(D) is true in every isosceles triangle?
(A) The three sides must have the same length.
(B) One side must have twice the length of another side.
(C) There must be at least two angles with the same measure.
(D) The three angles must have the same measure.
(E) None of (A)-(D) is true in every isosceles triangle.

10. Two circles with centers P and Q intersect at R and S to form a 4-sided figure PRQS. Here are two examples:

Which of (A)-(D) is not always true?
(A) PRQS will have two pairs of sides of equal length.
(B) PRQS will have at least two angles of equal measure.
(C) The lines PQ and RS will be perpendicular.
(D) Angles P and Q will have the same measure.
(E) All of (A)-(D) are true.
11. Here are two statements.

Statement 1: Figure F is a rectangle.
Statement 2: Figure F is a triangle.

Which is correct?

(A) If 1 is true, then 2 is true.
(B) If 1 is false, then 2 is true.
(C) 1 and 2 cannot both be true.
(D) 1 and 2 cannot both be false.
(E) None of (A)-(D) is correct.

12. Here are two statements.

Statement S: \( \triangle ABC \) has three sides of the same length.
Statement T: In \( \triangle ABC \), \( \angle B \) and \( \angle C \) have the same measure.

Which is correct?

(A) Statements S and T cannot both be true.
(B) If S is true, then T is true.
(C) If T is true, then S is true.
(D) If S is false, then T is false.
(E) None of (A)-(D) is correct.
13. Which of these can be called rectangles?

(A) All can.
(B) Q only
(C) R only
(D) P and Q only
(E) Q and R only

14. Which is true?
(A) All properties of rectangles are properties of all squares.
(B) All properties of squares are properties of all rectangles.
(C) All properties of rectangles are properties of all parallelograms.
(D) All properties of squares are properties of all parallelograms.
(E) None of (A)-(D) is true.

15. What do all rectangles have that some parallelograms do not have?
(A) opposite sides equal
(B) diagonals equal
(C) opposite sides parallel
(D) opposite angles equal
(E) none of (A)-(D)
16. Here is a right triangle ABC. Equilateral triangles ACE, ABF, and BCD have been constructed on the sides of ABC.

From this information, one can prove that $\overline{AD}$, $\overline{BE}$, and $\overline{CF}$ have a point in common. What would this proof tell you?

(A) Only in this triangle drawn can we be sure that $\overline{AD}$, $\overline{BE}$ and $\overline{CF}$ have a point in common.

(B) In some but not all right triangles, $\overline{AD}$, $\overline{BE}$ and $\overline{CF}$ have a point in common.

(C) In any right triangle, $\overline{AD}$, $\overline{BE}$ and $\overline{CF}$ have a point in common.

(D) In any triangle, $\overline{AD}$, $\overline{BE}$ and $\overline{CF}$ have a point in common.

(E) In any equilateral triangle, $\overline{AD}$, $\overline{BE}$ and $\overline{CF}$ have a point in common.

17. Here are three properties of a figure.

Property D: It has diagonals of equal length.

Property S: It is a square.

Property R: It is a rectangle.

Which is true?

(A) D implies S which implies R.

(B) D implies R which implies S.

(C) S implies R which implies D.

(D) R implies D which implies S.

(E) R implies S which implies D.
18. Here are two statements.

I. If a figure is a rectangle, then its diagonals bisect each other.
II. If the diagonals of a figure bisect each other, the figure is a rectangle.

Which is correct?

(A) To prove I is true, it is enough to prove that II is true.
(B) To prove II is true, it is enough to prove that I is true.
(C) To prove II is true, it is enough to find one rectangle whose diagonals bisect each other.
(D) To prove II is false, it is enough to find one non-rectangle whose diagonals bisect each other.
(E) None of (A)-(D) is correct.

19. In geometry:

(A) Every term can be defined and every true statement can be proved true.
(B) Every term can be defined but it is necessary to assume that certain statements are true.
(C) Some terms must be left undefined but every true statement can be proved true.
(D) Some terms must be left undefined and it is necessary to have some statements which are assumed true.
(E) None of (A)-(D) is correct.
20. Examine these three sentences.

(1) Two lines perpendicular to the same line are parallel.

(2) A line that is perpendicular to one of two parallel lines is perpendicular to the other.

(3) If two lines are equidistant, then they are parallel.

In the figure below, it is given that lines m and p are perpendicular and lines n and p are perpendicular. Which of the above sentences could be the reason that line m is parallel to line n?

(A) (1) only
(B) (2) only
(C) (3) only
(D) Either (1) or (2)
(E) Either (2) or (3)

21. In F-geometry, one that is different from the one you are used to, there are exactly four points and six lines. Every line contains exactly two points. If the points are P, Q, R, and S, the lines are \{P,Q\}, \{P,R\}, \{P,S\}, \{Q,R\}, \{Q,S\}, and \{R,S\}.

Here are how the words "intersect" and "parallel" are used in F-geometry. The lines \{P,Q\} and \{P,R\} intersect at P because \{P,Q\} and \{P,R\} have P in common.

The lines \{P,Q\} and \{R,S\} are parallel because they have no points in common.

From this information, which is correct?

(A) \{P,R\} and \{Q,S\} intersect.
(B) \{P,R\} and \{Q,S\} are parallel.
(C) \{Q,R\} and \{R,S\} are parallel.
(D) \{P,S\} and \{Q,R\} intersect.
(E) None of (A)-(D) is correct.
22. To trisect an angle means to divide it into three parts of equal measure. In 1847, P.L. Wantzel proved that, in general, it is impossible to trisect angles using only a compass and an unmarked ruler. From his proof, what can you conclude?

(A) In general, it is impossible to bisect angles using only a compass and an unmarked ruler.

(B) In general, it is impossible to trisect angles using only a compass and a marked ruler.

(C) In general, it is impossible to trisect angles using any drawing instruments.

(D) It is still possible that in the future someone may find a general way to trisect angles using only a compass and an unmarked ruler.

(E) No one will ever be able to find a general method for trisecting angles using only a compass and an unmarked ruler.

23. There is a geometry invented by a mathematician J in which the following is true:

The sum of the measures of the angles of a triangle is less than 180°.

Which is correct?

(A) J made a mistake in measuring the angles of the triangle.

(B) J made a mistake in logical reasoning.

(C) J has a wrong idea of what is meant by "true."

(D) J started with different assumptions than those in the usual geometry.

(E) None of (A)-(D) is correct.
24. Two geometry books define the word rectangle in different ways. Which is true?
   (A) One of the books has an error.
   (B) One of the definitions is wrong. There cannot be two different definitions for rectangle.
   (C) The rectangles in one of the books must have different properties from those in the other book.
   (D) The rectangles in one of the books must have the same properties as those in the other book.
   (E) The properties of rectangles in the two books might be different.

25. Suppose you have proved statements I and II.
   I. If p, then q.
   II. If s, then not q.

   Which statement follows from statements I and II?
   (A) If p, then s.
   (B) If not p, then not q.
   (C) If p or q, then s.
   (D) If s, then not p.
   (E) If not s, then p.
COURSE INTEREST SURVEY (CIS)

1. The instructor knows how to make us feel enthusiastic about the subject matter of this course
2. The things I am learning in this course will be useful to me
3. I feel confident that I will do well in this course
4. This class has very little in it that captures my attention
5. The instructor makes the subject matter of this course seem important
6. You have to be lucky to get good grades in this course
7. I have to work too hard to succeed in this course
8. I do NOT see how the content of this course relates to anything I already know
9. Whether or not I succeed in this course is up to me
10. The instructor creates suspense when building up to a point
11. The subject matter of this course is just too difficult for me
12. I feel that this course gives me a lot of satisfaction
13. In this class, I try to set and achieve high standards of excellence
14. I feel that the grades or other recognition I receive are fair compared to other students
15. The students in this class seem curious about the subject matter
16. I enjoy working for this course
17. It is difficult to predict what grade the instructor will give my assignments
18. I am pleased with the instructor’s evaluations of my work compared to how well I think I have done
19. I feel satisfied with what I am getting from this course
20. The content of this course relates to my expectations and goals
21. The instructor does unusual and surprising things that are interesting
22. The students actively participate in this class
23. To accomplish my goals, it is important that I do well in this course
24. The instructor uses an interesting variety of teaching techniques
25. I do NOT think I will benefit much from this course
26. I often dream while in this class
27. As I am taking this class, I believe that I can succeed if I try hard enough
28. The personal benefits of this course are clear to me
29. My curiosity is often stimulated by the questions asked or the problems given on the subject matter in this class
30. I find the challenge level in this course to be about right neither too easy nor too hard
31. I feel rather disappointed with this course
32. I feel that I get enough recognition of my work in this course by means of grades, comments, or other feedback
33. The amount of work I have to do is appropriate for this type of course
34. I get enough feedback to know how well I am doing
APPENDIX B

Human Subject Committee, Leon County Schools Approval Letters, Consent Letters, and School Permissions
APPROVAL MEMORANDUM
from the Human Subjects Committee

Date: March 29, 2002
From: David Quadagno, Chair
To: Erdogan Halat
925 E. Magnolia Drive #6-8
Tallahassee, FL 32301
Dept: Curriculum and Instruction
Re: Use of Human Subjects in Research
Projects entitled: The Role of Instructional Method in Geometry

The forms that you submitted to this office in regard to the use of human subjects in the proposal referenced above have been reviewed by the Human Subjects Committee at its meeting on March 21, 2002. Your project was approved by the Committee.

The Human Subjects Committee has not evaluated your proposal for scientific merit, except to weigh the risk to the human participants and the aspects of the proposal related to potential risk and benefit. This approval does not replace any departmental or other approvals which may be required.

If the project has not been completed by March 20, 2003 you must request renewed approval for continuation of the project.

You are advised that any change in protocol in this project must be approved by resubmission of the project to the Committee for approval. Also, the principal investigator must promptly report, in writing, any unexpected problems causing risks to research subjects or others.

By copy of this memorandum, the chairman of your department and/or your major professor is reminded that he/she is responsible for being informed concerning research projects involving human subjects in the department, and should review protocols of such investigations as often as needed to insure that the project is being conducted in compliance with our institution and with DHHS regulations.

This institution has an Assurance on file with the Office for Protection from Research Risks. The Assurance Number is IRB00000446.

Cc: Elizabeth Jakubowski
APPLICATION NO.02.038
Parent Consent Letter

I consent to participating in (or my child's participation in) research entitled:

The Role of Instructional Method in Geometry

Erdogan Halat (principal investigator) or his authorized representative has explained the purpose of the study, the procedures to be followed, and the expected duration of my (child's) participation. Possible benefits of the study have been described as have alternative procedures, if such procedures are applicable and available.

I acknowledge that I have had the opportunity to obtain additional information regarding the study and that any questions I have raised have been answered to my full satisfaction. Furthermore, I understand that I am (my child is) free to withdraw consent at any time to discontinue participation in the study without prejudice to me (my child).

I understand that there will be Pre- and Posttest involved in the study. The participants will use their names on answer sheets in order to help the researcher to match up both pre- and posttests. In addition, I understand that the data will be kept confidential to the extent allowed by law and that the data will be destroyed at the end of the study or by December 31, 2003.

Finally, I acknowledge that I have read and fully understand the consent form. I sign it freely and voluntarily. A copy has been given to me.

Date: ....................... Signed: ........................................
(Participant)

Signed: ....................... Signed: ........................................
(Principal Investigator or his authorized representative) (person authorized to consent for participant- parent)
Child Assent Letter

I have been informed that my parent(s) have given permission for me to participate, if I want to, in a study concerning

*The Role of Instructional Method in Geometry.*

I will take a geometry test and a motivation test in a regular class hour. My participation in this study is voluntary and I have been told that I may stop my participation in this study at any time. If I choose not to participate, it will not affect my grade in any way. I understand that I will be taped recorded by the researcher. These tapes will be kept by the researcher in a locked cabinet. I understand that only the researcher will have access to these tapes and that they will be destroyed by December 20, 2003. I understand that my participation will remain confidential.

I have read and fully understand the consent form. I sign it freely and voluntarily.

Signed: ........................................
(Participant)
February 8, 2002

Mr. Erdoğan Halat
925 E. Magnolia Dr. #G-5
Tallahassee, Florida 32301

Topic: “The Role of Instructional Method in Geometry”

Dear Mr. Halat:

The Leon County Research Review Board has approved your request for research. Based on your proposal, the research will be approved for the period of February 2002 through June 2002. Should you desire to continue your research efforts after this period of time, you must submit a progress report on the status of your research and request renewed approval for continuation of the project. Any significant changes or amendments to the procedures or design of this study must be approved by resubmitting the request for research to the Research Review Board.

You need to contact the principals of the schools in which you wish to conduct your study as soon as possible. The principal is responsible for making the decision relative to his or her school participation in this study. It is your responsibility to return the enclosed “Principal’s Consent for Research Participation,” signed by the principal(s) of the school(s) to be involved, prior to the start of any research. Receipt of this consent form by this office will complete the approval process.

In the interest of continued research benefits and the coordination of research interests, please send this office one copy of your results and discussion. This information, and any other relevant information you may have, will be filed in our research library and added to the annotated listing of research projects.

Please feel free to call me if I can of further assistance. I can be reached at 488-7007.

Sincerely,

[Signature]
Margarita J. Southard, Ph.D
Program Monitoring and Evaluation
Chair, Research Review Board

MPS/db
Attachment

cc: Committee members; Marvin Henderson, Kae Ingram, Paul Felsch, Steve Ash, and Sakira Abdulla
Leon County Schools
Principal's Consent for Research

<table>
<thead>
<tr>
<th>Principal Investigator</th>
<th>Topic of Study</th>
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<tbody>
<tr>
<td>Erdogan Halat</td>
<td>The role of Constructivist Method</td>
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I have met with the above-named researcher and we have discussed the research proposal as approved by the LCS Research Board. I hereby give my permission to conduct the research as proposed in my school.

<table>
<thead>
<tr>
<th>Participating School(s)</th>
<th>Signature of Principal</th>
<th>Date</th>
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<tbody>
<tr>
<td>R. Frank Ains H.S.</td>
<td>Gena Crawford</td>
<td>2-25-02</td>
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TO COMPLETE THE APPROVAL PROCESS, THIS FORM MUST BE RETURNED TO THE CHAIRPERSON, RESEARCH REVIEW BOARD, PROGRAM MONITORING & EVALUATION SERVICES (3955 W. PENSACOLA ST, TALLAHASSEE, FL 32304) PRIOR TO THE START OF ANY RESEARCH.

I verify that this list is complete and that any significant amendments to this research will be first approved by the Research Advisory Board Chairperson and the principals at the above school site(s).

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<th>Signature of Principal Investigator</th>
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<tr>
<td>Erdogan Halat</td>
<td>2/25/02</td>
</tr>
</tbody>
</table>
**Leon County Schools**

**Principal's Consent for Research**

<table>
<thead>
<tr>
<th>Principal Investigator</th>
<th>Topic of Study</th>
</tr>
</thead>
<tbody>
<tr>
<td>Erdogan Halat</td>
<td>The Role of Instructional Methods in Secondary</td>
</tr>
</tbody>
</table>

I have met with the above-named researcher and we have discussed the research proposal as approved by the LCS Research Board. I hereby give my permission to conduct the research as proposed in my school.

<table>
<thead>
<tr>
<th>Participating School(s)</th>
<th>Signature of Principal</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kellieville Middle</td>
<td></td>
<td>2/18/02</td>
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</tbody>
</table>

TO COMPLETE THE APPROVAL PROCESS, THIS FORM MUST BE RETURNED TO THE CHAIRPERSON, RESEARCH REVIEW BOARD, PROGRAM MONITORING & EVALUATION SERVICES (3555 W. PENSACOLA ST, TALLAHASSEE, FL 32304) PRIOR TO THE START OF ANY RESEARCH.

I verify that this list is complete and that any significant amendments to this research will be first approved by the Research Advisory Board Chairperson and the principals at the above school site(s).

<table>
<thead>
<tr>
<th>Signature of Principal Investigator</th>
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</table>

**Program Monitoring & Evaluation**

3555 W. Pensacola St • Tallahassee, FL 32304
Malinda Jackson, Equity Coordinator
An Affirmative/Equal Opportunity Employer
Date: Sat, 16 Mar 2002 04:48:42 -0600
From: z-usiskin@uchicago.edu
To: "Erdogan Halat" <erdoganhalat@yahoo.com>
Subject: Re: Van Hiele Test

Dear Mr. Halat:

Thank you very much for the information. It is clear that you have thought very clearly about this study. You have our permission to use the van Hiele test in your study.

Zalman Usiskin (from Singapore)
REFERENCES


BIOGRAPHICAL SKETCH

Erdogan Halat was born in Yozgat, Turkey in 1970, and graduated from Selcuk University in 1993 with a Bachelor of Science Degree in Mathematics Education. After teaching middle and high school mathematics in a private institution, Zagnos Dershanesi, for two years, he was awarded with a full scholarship for Masters and PhD in Mathematics Education and sent to the United States. He got his Masters of Arts Degree in Mathematics Education from the Ohio State University in December 1998. He started his PhD programs in the Department of Middle & Secondary Education at the Florida State University in January 1999, and graduating with a Doctor of Philosophy Degree in December 2003. During this period of time, he taught a geometry course for a semester and worked as a research assistant for a year in the Department of Middle & Secondary Education at FSU, and taught two sections of Intermediate Algebra as an adjunct instructor for a semester at the Tallahassee Community College.

He is happily married with his dear wife, Saliha, and is the father of a daughter, Rana, who was born in Tallahassee, Florida, and now is a little student of YMCA.