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Sex-Related Differences In The Acquisition Of The Van Hiele Levels And Motivation In Learning Geometry

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The purpose of this study was to examine the acquisition of the van Hiele levels and motivation of sixth-grade students engaged in instruction using van Hiele theory-based mathematics curricula. There were 150 sixth-grade students, 66 boys and 84 girls, involved in the study. The researcher employed a multiple-choice geometry test to find out students' reasoning stages and a questionnaire to detect students' motivation in regards to the instruction. These instruments were administered to the students before and after a five-week period of instruction. The paired-samples t-test, the independent-samples t-test, and ANCOVA with $\alpha = .05$ were used to analyze the quantitative data. The study demonstrated that there was no statistically significant difference as in motivation between boys and girls, and that no significant difference was detected in the acquisition of the levels between boys and girls. In other words, gender was not a factor in learning geometry.

Key words: Gender; van Hiele theory-based curriculum; van Hiele levels; motivation; middle school; geometry

Introduction

Research has documented that many students encounter difficulties and show poor performance in geometry classrooms in both middle and high schools (e.g., Usiskin, 1982; Fuys, Geddes, & Tischler, 1988; Gutierrez, Jaime, & Fortuny, 1991). Moreover, research shows a decline in students' motivation toward mathematics courses (c.f., Gottfried, Fleming & Gottfried, 2001). In fact, Ryan & Pintrich (1997), Keller (1999) and Dev (1998) claimed that there is a positive correlation between student achievement and motivation in mathematics.

What might be the reasons behind students' low achievement and negative attitudes towards mathematics courses? There might be many internal and external factors, such as feeling valued, perception of cognitive competence, perception of parental support, environment, task difficulty, gender, curriculum, and so forth seeming to play vital roles in achievement and motivation in the mathematics classroom (e.g., Driscoll, 1994; Reeve, 1996; Wentzel, 1997; Middleton, 1999; Alderman, 1999; Chapell, 2003; Young-Loveridge, 2005). The effects of some of these variables on students learning have been investigated and the results are reported. In particular, sex differences in academic achievement in mathematics have been the subject of extensive examination over the last two decades (e.g., Smith & Walker, 1988; Fan & Chen, 1997). Moreover, Forgasız (2005) for whom gender is still a matter of concern in mathematics education argued that it is significantly important to include gender as a variable in research analysis even if it is not the main focus of a study.

Gender Differences in Geometry at the Middle School Level

Many of the research findings showed that sex differences in mathematics are varied at middle school levels. Evidence on when sex differences in perceptions of competence in mathematics start to occur is not entirely consistent. Several

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studies have found that there is a sex difference between boys and girls in learning geometry. For instance, according to Armstrong (1981), thirteen-year-old girls performed better at computation and spatial visualization than boys. However, Fennema & Carpenter (1981) indicated that "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). This result supports the finding of Maccoby & Jacklin (1974) stating that 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 numeration skills.

Likewise, according to Fennema & Sherman (1978), variables, such as mathematics as being a male domain, confidence in learning mathematics, attitudes toward success, spatial visualization, mathematics computation, comprehension, application, problem-solving, verbal ability, usefulness, effectance motivation, parental involvement and teacher were vital in student achievement with regard to sex differences in mathematics. Among these variables they identified two significant sex-related effective variables, which were confidence in learning mathematics, and mathematics as a male domain.

However, there are others claiming that there is no difference between the sexes in geometry. For example, Armstrong (1981) expressed the view that there was no difference in the achievement of boys and girls at the sixth grade level in the skills of measurement applications, geometry applications, and probability/statistics. This was in line with the claim of Fennema & Sherman (1978) who found that there were no statistically significant sex-related differences in spatial visualization and that there was no significant sex-related difference in motivation between boys and girls in mathematics. These results support the argument of Ryan & Pintrich (1997) and Dev (1998) stating that there is a positive correlation between student achievement and motivation in mathematics.

According to Armstrong (1981), the problem-solving abilities of boys and girls at this age, 13, 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 claimed that this phenomenon had changed by the end of high school.

Variables Affecting Sex Differences

Over the past few decades, research has documented that although there is a difference between the achievement of male and female students in many content areas of mathematics, such as spatial visualization, problem solving, computation, measurement applications and so forth (e.g., Jones, 1989; Grossman & Grossman, 1994; Lloyd, Walsh & Yailagh, 2005), in recent years a considerable decrease can be seen in the gender gap between male and female students' attitudes towards mathematics (e.g., Friedman, 1994; Fennema & Hart, 1994). However, according to Hyde, Fennema & Lamon (1990) and Malpass, O'Neil & Hocevar (1999), there is also a considerable increase in the gender gap among gifted or high scoring students on mathematics tests. There are some factors, such as prior achievement, value, stereotyping mathematics as a male domain, and curriculum appearing to play vital roles in the sex differences between boys and girls in mathematics (e.g., Fennema & Sherman, 1978; Becker, 1981; Ethington, 1992; Grossman & Grossman, 1994).

Researchers investigated the effects of some of these variables as factors in the achievement of boys and girls. For instance, according to Grossman & Grossman (1994), some girls scoring lower than boys on mathematics achievement tests are not less skilled mathematicians. They said that girls score lower because they become anxious when they take such tests and because test items are biased against girls. Besides, it seems that girls' perceptions of valuing success in mathematics is totally different from that of boys. Nicholls, Cobb, Wood, & Yackel (1989) claimed that boys believed that their success depended on their superior ability, whereas girls believed that theirs depended on collaboration with others and an attempt to understand. Neither value nor expectations for success had a significant impact on achievement for females (Ethington, 1992).

Likewise, Fennema & Sherman (1978) pointed out that males considered mathematics to be more useful than females did and their parent's input as a more positive factor toward mathematics learning than females did. 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 effects on the achievement for females.

Middleton & Spanis (1999) stated that students' perception of success in mathematics had a great effect on their motivational attitudes. Wentzel (1998) posits that parental support, peer help and teacher care were vital factors playing important roles in learning. This was consistent with the claim of Hanna, Kundiger & Larouche (1990) stating that parental support was an important variable affecting student achievement based on sex differences in mathematics. However, Stipek (1998) claimed that teachers had more influence on student motivation in learning mathematics than parents did because of the fact that students spend most of their times in schools. In addition, students who felt supported and valued by their teachers were willing to engage in classroom activities and were highly motivated to be successful in mathematics class (Wentzel, 1997).

In summary, the role of instruction is crucial in teaching and learning geometry as expressed by Usiskin (1982), Fuys, Geddes, & Tischler (1988), and Messick & Reynolds (1992). Moreover, the more systematically structured the instruction, the more helpful it will be for middle school students to overcome their difficulties and to increase their understanding of geometry. Fennema & Hart (1994) claimed that interventions could achieve equity in learning mathematics. Likewise, instruction influenced by the van Hiele theory-based curricula may cause changes in girls' negative attitudes towards mathematics courses because reform-based works in mathematics teaching and learning, such as the New Zealand Numeracy Projects (NZNP) (Young-Loveridge, 2005) and standard-based curricula, such as "Everyday Math" and "MathThematics" have positive impacts on student achievement and motivation in mathematics (e.g., Billstein & Williamson, 2003; Chapell, 2003).

The Van Hiele Theory

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. 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). Studies (e.g., Mayberry, 1983; Hoffer, 1986; van Hiele, 1986) have proposed that movement from one level to the next level includes five phases: information, bound (guided) orientation, explicitation, free orientation, and integration. Today, this model is a foundation for curricula implemented in mathematics classrooms. Research since the early 1980s has helped to confirm the validity of the theory (e.g., Usiskin, 1982; Mayberry, 1983; Fuys, Geddes, & Tischler, 1988).

Research has been completed on various components of this teaching and learning model. Wirszup (1976) reported the first study of the van Hiele theory, which attracted educators' attention at that time in the United States. In 1981, Hoffer worked on the description of the levels. Usiskin (1982) affirmed the validity of the existence of the 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. Fuys, Geddes, and Tischler (1988) examined the effects of instruction on a student's predominant Van Hiele level. Briefly, some of these 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 the van Hiele levels.

Moreover, there were some studies done with pre-service elementary and secondary mathematics teachers regarding their reasoning stages in geometry. For instance, Knight (2006) conducted a research exercise with a total of 68 pre-service elementary (46) & secondary (22) mathematics teachers. She found that the pre-service elementary and secondary mathematics teachers reasoning stages were below level-III (informal deduction) and level-IV (deduction), respectively (Knight, 2006). Her findings are surprising because the van Hiele levels of pre-service elementary and secondary mathematics teachers are lower than the level expected of students completing grade 8 and grade 12, respectively. These results are consistent with the findings of Gutierrez, Jaime, & Fortuny (1991), Mayberry (1983), Duatepe (2000), and Olkun, Toluk, & Durmuş (2002). In other words, none of the pre-service elementary and secondary mathematics teachers showed a level-V (Rigor) reasoning stage in geometry.

For this report, all references and all results from research studies using the 0-4 scale have been changed to the 0-5 schema: Level-0 (Pre-recognition), Level-I (Visualization), Level-II (Analysis), Level-III (Ordering: Informal deduction), Level-IV (Deduction) and level-V (Rigor).

The existence of level-0 is the subject of some controversy (e.g., Usiskin, 1982; Burger & Shaughnessy, 1986). Van Hiele (1986) does not talk about or acknowledge the existence of such a level. However, Clements and Battista (1990) have described and defined level-0 (Pre-recognition) 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 among any of the quadrilaterals (Mason, 1997).

Purpose of the Study

The study focused on the effects of an instruction shaped by the van Hiele theory-based curricula on the acquisition of the van Hiele levels in geometry and students' attitudes toward a geometry class. The following questions guided the study:

1. Is gender a factor in the acquisition of the van Hiele levels in geometry?

2. What differences exist with regard to motivation between boys and girls instructed with the van Hiele theory-based curricula?

The researcher agrees with the recommendation of the National Council of Teachers of Mathematics NCTM (2000) 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).

Definitions

Van Hiele Theory-based curriculum was a geometry curriculum in which the authors designed teaching materials based on educational theories, in particular the van Hiele theory. The implementation of this theory in geometry classrooms was recommended by the NCTM (2000).

Traditional curriculum was a regular mathematics curriculum in which the authors did not implement the characteristics of the van Hiele theory in their presentation of geometry.

Methodology

Methods of Inquiry

Quasi-experimental statistical design was used in the study. The researcher divided the participants into two groups based on gender, but the participants were not randomly selected and assigned to the groups (McMillan, 2000). He 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-tests and post-tests were given to the participants before and after the instruction as an independent variable.

Participants

In this study the researcher followed the "convenience" sampling procedure defined by McMillan (2000), where a group of participants is selected because of availability. Participants in the study were sixth-grade students enrolled in six mathematics classes at a public middle school in north Florida, USA. The researcher chose this school based on the curriculum practice. The total number of students involved in the study was 150. The majority of the students were from low socio-economic income families. In other words, almost 80 percent of the students involved in the study were eligible for the federal free and reduced-price lunch program as reported by the state. This percentage was one indication of the student economic level (or family income level) at a school.

Data Sources

The data collection processes started with giving students a geometry test called the *Van Hiele Geometry Test (VHGT)* and a questionnaire, the course interest survey (CIS) used as a pre-test and post-test in the study. The VHGT was 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. The VHGT was taken from the study of Usiskin (1982) with his written permission. The VHGT is designed to measure one's van Hiele level in geometry.

The questionnaire *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, this questionnaire was administered for 15 minutes. The CIS was taken from the study of Keller (1999) with his oral permission. The course interest survey is designed to evaluate a situational measure of 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. Students in both groups of the study met for an hours instruction in a day for five days a week.

Instructional Curricula

The instruction followed the Connected Mathematics Project's (CMP) *Shapes and Designs* (Lappan, Fey, Fitzgerald, Friel, & Phillips, 1996), and was supported by *Discovering Geometry: An Inductive Approach* (Serra, 1997) in which textbook authors wrote their materials based on the characteristics of the van Hiele theory. Two female mathematics teachers involved in this study attended CMP's training programs. Both teachers implemented the CMP's instructional model, launched, explored and summarized, in their teaching of geometry. The topics, consisting of polygons, such as triangles and quadrilaterals, angle relations, properties, and transformation and tessellation, were taught during the five weeks of instruction.

Test Scoring Guide

All students' answer sheets from VHGT were read and scored by the investigator. All students received a score referring to a van Hiele level from the VHGT guided by Usiskin's grading system.

"For the 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)" (1982, p. 22)

The 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" (p.41).

Analysis of Data

The data were responses from students' answer sheets. In the process of the assessment of students' van Hiele levels, the criterion for success at any given level was three out of five correct responses. First, the researcher conducted the independent-samples t-test statistical procedure with $\alpha = .05$ on the students' pretest scores from both the VHGT and CIS to determine any differences in terms of the acquisition of the levels and motivation between boys and girls. This t-test procedure showed means score differences in terms of levels and motivation between the two groups favoring the boy's group. Then, scores from both the VHGT and CIS were compared using one-way analysis of covariance (ANCOVA) with $\alpha = .05$, which is a variation of ANOVA, to adjust for pretest differences that existed between two 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 with regard to van Hiele levels and motivation between the groups, ANCOVA was employed to analyze the quantitative data in the study. The pretest scores from both the Van Hiele Geometry Test and the Course Interest Survey served as the covariates in the analysis of students' levels and motivation by curricula and gender effect. ANCOVA enabled the researcher to compare both the VHGT scores and motivation of each group.

Furthermore, the paired-samples t-test with $\alpha = .05$ was used to detect the mean differences between pre-test and post-test 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 the attainment of the levels and motivation for each group. Finally, the researcher constructed frequency tables to acquire further information about students' van Hiele level distributions for both groups.

Results

Question 1. Is gender a factor in the acquisition of the van Hiele levels in geometry?

Table 1 presents the descriptive statistics for boys' van Hiele levels, and indicates that the boys' mean score is numerically higher than that of the girls. The analysis of covariance (ANCOVA) as shown in Table 2 below, however, indicates that this difference is not statistically significant in terms of the van Hiele levels in geometry between boys and girls, [$F\ (1, 149) = 2.446$; $p > .05$]. While it seems that there is a gain favoring boys based on their levels, it is not statistically significant. Table 3 shows that the progress of boys from level-0 to higher levels is almost equal to the progress of girls. Boys and girls are mostly at level-I. Therefore, no gender differences were found in the study.

Question 2. What differences exist with regard to motivation between boys and girls instructed with the van Hiele theory-based curricula?

Table 4 presents the descriptive statistics for boys' motivation based on the CIS scores, and shows that the boys' mean score (130.575^a) is numerically higher than that of the girls (128.715^a). Table 5, the analysis of covariance (ANCOVA), indicates that gender does not have an effect on students' motivation in learning geometry, [$F\ (1,149) = 1.549$; $p > .05$].

Table 1. *Descriptive Statistics for Students' van Hiele Levels by Gender*

Gender	N	Pretest		Posttest		Posttest*	
		M	SD	M	SD	M	SE
Male	66	.71	.57	1.15	.76	1.141^a	.08
Female	84	.67	.58	.96	.63	$.972^a$	.07
Total	150						

Note. a: Evaluated at covariates appeared in the model: Pre- level = .69. *Estimated Marginal Means.

Table 2. *Summary of ANCOVA for Students' van Hiele levels by Gender*

Sources	Sum of Squares	df	Mean Square	F-statistic
Pretest	7.872	1	7.872	18.223
Gender	1.057	1	1.057	2.446

Note. P>.05

Table 3. *Frequency Table for Students' van Hiele Levels by Gender*

Groups	N		Level-0		Level-I		Level-II	
			n	%	n	%	n	%
Male	66	Pre- levels	23	34.8	39	59.1	4	6.1
		Post- levels	10	15.2	41	62.1	15	22.7
Female	84	Pre- levels	33	39.3	46	54.8	5	6
		Post- levels	16	19	57	67.9	11	13.1

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

Table 4. *Descriptive Statistics for Students' overall Motivation based on the CIS Scores by Gender*

Gender	N	Pretest		Posttest		Posttest*	
		M	SD	M	SD	M	SE
Boys	66	121.14	15.96	131.50	14.64	130.575[a]	1.1
Girls	84	118.76	14.85	127.99	13.43	128.715[a]	0.9
Total	150						

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

Table 5. *Summary of ANCOVA for Students' overall Motivation Based on the CIS Scores by Gender*

Sources	Sum of Squares	df	Mean Square	F-statistic
Pretest	16869.864	1	16869.864	205.532
Gender	127.158	1	127.158	1.549

Note. α = .05, CIS: Course Interest Survey.

Summary

In both cases, the study showed that there was no statistically significant difference in terms of the acquisition of the van Hiele levels in learning geometry between boys and girls. Likewise, the study did not detect a significant difference between two groups as in the students' attitudes toward the geometry course taught by an instruction designed according to van Hiele theory-based curricula.

Discussion & Conclusion

Students' Overall Reasoning Stages in Geometry

None of the sixth-grade students in the study progressed beyond level-II (analysis). Most students' van Hiele geometry levels were level-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 generally level-I reasoning took place in grades K-8. This supports the idea that younger students and many adults in the United States reason at levels-I (visualization) and –II (analysis) of the van Hiele scale (Usiskin, 1982; Hoffer, 1986; Knight, 2006). It could be inferred from the result of this study and others mentioned above that a geometry curriculum would be more practical and useful if it focuses on level-I (visualization) and –II (analysis) geometry knowledge at sixth grade level.

Gender Differences

Data in the present study revealed that gender did not have an effect on students learning in geometry. That is, both boys and girls instructed with the van Hiele theory-based curricula showed similar reasoning stages in geometry. In addition, both groups' motivational attitudes toward geometry classes were equal. This is in line with the claim of Stipek (1998) and Middleton & Spanias (1999) stating carefully structured instructional design including clear and meaningful task activities and level of difficulty had a great impact on student achievement and motivation in mathematics. Likewise, Ryan & Pintrich (1997) and Dev (1998) stated that there was a positive correlation between student achievement and motivation in learning mathematics. The result of this study is also consistent with the finding of Lappan, Reys, Barnes, and Reys (1998) claiming that no gender differences were found in mathematics achievement at the sixth grade level. Moreover, the findings of Armstrong (1981) and Fennema & Sherman (1978) support this result. Armstrong (1981) found that there was no difference in the achievement of boys and girls at 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 were no significant sex-related differences in spatial visualization. However, according to Fennema & Carpenter (1981), girls at the middle school level (13-year-old students involved in the study) performed poorly on geometry and measurement exercises involving spatial visualization skills. It seems that there is a contradiction between the results of the studies mentioned above. According to Fennema & Hart (1994), the type of school, quality of teachers, socio-economics status and ethnicity of students might be some of the reasons which may help explain this contradiction.

In short, the results of this current study support the observation that in recent years a considerable decrease can be seen in the gender gap between male and female students in many content areas of mathematics, such as spatial visualization, reasoning, problem solving and computation (e.g., Friedman, 1994; Lynn & Hyde, 1989; Hart, 1992; Fennema & Hart, 1994).

Implications & Recommendations

This current study revealed that no significant sex-related difference was found between boys and girls instructed with the van Hiele theory-based curricula in regard to the attainment of the van Hiele levels and motivation in the geometry classes. The instruction influenced by the van Hiele theory-based curricula might be one of the factors that may have helped girls to overcome the perception of mathematics as a male domain. In other words, if girls study geometry from the van Hiele theory-based curricula, they may overcome the idea that mathematics is a male domain. Similarly, if mathematics teachers teach geometry from the van Hiele theory-based curricula, they may help girls to maintain their confidence in learning geometry.

Leder (2005) expressed that females' mathematics performance is somehow insufficient, but they can reach the achievement of males with stronger effort, different practices or better interventions. Furthermore, Fennema & Hart (1994) mentioned that interventions could achieve equity in learning mathematics. The findings of this study also showed that teaching or learning geometry from the van Hiele theory-based curricula may achieve equity in mathematics classrooms. This is in line with an argument stating that reform-based works in mathematics teaching and learning (Young-Loveridge, 2005) and standard-based curricula have positive effects on student achievement and motivation in mathematics (e.g., Billstein & Williamson, 2003; Chapell, 2003).

Limitations

A student can perform better in one area; yet not exhibit the same performance level in other areas (Fuys et al., 1988; Burger & Shaughnessy, 1986). Geometry topics investigated in this study were polygons and tessellations. The findings of the study can not be applied to all geometry topics. Furthermore, the study took place over the course of only five weeks. This author thinks that the duration of time given by the schools for the topics to be covered was insufficient. Time constraint also pushed the teachers to limit their instruction and limit the student interaction 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 classroom. In addition, the vast majority of the students were from low socio-economic income families. Therefore, these findings should not be assumed to be able to be readily generalized to students from other socio-economic backgrounds.

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