Eurasia Journal of Mathematics, Science & Technology Education, 2007, **3**(1), 41-49

www.ejmste.com

Reform- Based Curriculum & Acquisition of the Levels

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Received 10 June 2006; accepted 07 December 2006

The aim of this study was to compare the acquisition of the van Hiele levels of sixth-grade students engaged in instruction using a reform-based curriculum with sixth-grade students engaged in instruction using a traditional curriculum. There were 273 sixth-grade mathematics students, 123 in the control group and 150 in the treatment group, involved in the study. The researcher administered a multiple-choice geometry test to the students before and after a five - week of instruction. The test was designed to detect students' reasoning stages in geometry. The independent-samples t-test, the paired-samples t-test and ANCOVA with $\alpha = .05$ were used to analyze the data. The study demonstrated that although both types of instructions had positive impacts on the students' progress, there was no statistical significant difference detected in the acquisition of the levels between the groups.

Keywords: Curriculum, Middle School, Acquisition of Levels, Geometry

INTRODUCTION

Van Hiele Theory Based Curricula & Acquisition of the Levels

Over the past few decades, researchers have found that many students encounter cognitive difficulties in learning geometry in both middle and high schools (e.g., Hoffer, 1981; Usiskin, 1982; Burger & Shaughnessy, 1986; Crowley, 1987; Fuys, Geddes, & Tischler, 1988; Gutierrez, Jaime, & Fortuny, 1991; Mason, 1997). Moreover, 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 fourth graders' achievements in the United States in mathematics were at the top level among students from 38 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.

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Usiskin's study (1982) indicates that many students fail to grasp key concepts in geometry, and leave their geometry classes 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, but if the activities are not challenging, 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 (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

ISSN: 1305-8223

is a positive correlation between students' achievement 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' accomplishment 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 other approaches, such as student-centered, cooperative learning, and discovery learning are recommended for the teachers to enhance the effectiveness of their teaching and students' learning. These approaches also should not be utilized 100 percent of the time (Skemp, 1987; 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).

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. In responding to this variation, the instructors show different ways for students to succeed based on their learning styles. Furthermore, it is also 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.

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). However, 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.

Purpose of the Study

The study focused on the comparison of effects of curricula on the students' acquisition of the levels in geometry at the middle school level. This focus was based on concerns expressed by Crowley (1987) as "the need … 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). While the students in the treatment group were exposed to an instruction using a reform-based curriculum designed on the van Hiele theory, the others in the control group were exposed to an instruction following a traditional one. The following question guided the study:

What differences exist between students who were instructed with a reform-based curriculum and students instructed with a conventional one with reference to the acquisition of the levels in geometry?

The researcher agrees with the recommendation of 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). Furthermore, standard-based curricula have positive impact 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 reasoning stages and instructional phases in geometry. Many researchers have studied and confirmed different aspects of the theory since proposed by the van Hieles. The present study adds to the set of studies by examining the validity of the van Hiele theory in terms of curricula.

Theoretical Framework

The National Council of Teachers of Mathematics (2000) suggests that new ideas, theories, research findings and approaches be utilized in teaching and learning mathematics, especially the van Hiele theory in geometry. 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., Hoffer, 1981; 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 van Hiele levels.

In this study, the 1-5 scheme 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. For this report, all references and all results from research studies using the 0-4 scale have been changed to the 1-5 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 among any of the quadrilaterals (Mason, 1997).

METHODOLOGY

Methods of Inquiry

Quasi-experimental statistical design was used in the study. The researcher employed 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 study, while the experimental (treatment) group included students who were instructed with the reform-based curricula, the control group comprised students who were instructed with a curriculum not designed based on the van Hiele theory.

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-test and post-test were given to the participants before and after the instruction as an independent variable. The researcher investigated the effects of an instruction using a reform-based curriculum on the students' attainment of the levels in geometry. The comparison of students' attainment of levels was made in the study. Therefore, this experimental approach enabled the researcher to evaluate the effectiveness of an instruction using a curriculum based on the van Hiele-theory with the results of the geometry test in mathematics classroom.

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 twelve mathematics classes at two public middle schools in north Florida. The researcher chose these two schools based on their curriculum practices and permissions of the schools' principals. One of these was following a reform-based curriculum, and the other one was using a traditional 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 a geometry test called *Van Hiele Geometry Test (VHGT)* used as 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 students' van Hiele levels in geometry. There are some questions or examples found in the (non-Van Hiele based) *Middle School Math Course-I* 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, "(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 possibility that the VHGT test being used was biased towards the curricula designed based on the van Hiele theory. In the study, students in both groups met for one hour of geometry instruction a day for five days per week.

Instructional Curricula

The instruction following the van Hiele theory-based materials used curricula designed on the van Hiele theory, based on *Shapes and Designs* (Lappan, Fey, Fitzgerald, Friel, & Phillips, 1996) and *Discovering Geometry: An Inductive Approach* (Serra, 1997) 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 following the traditional curriculum that was based on *Middle School Math Course I* (Charles, Dossey, Leinwand, Seeley, & Embse, 1998) not designed on the van Hiele theory and addressed 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 taught during the five weeks of instruction. The mathematics teachers using the reform-based curricula implemented the CMP's instructional model, launch, explore and summarize, in their teaching of geometry.

Test Scoring Guide

All students' answer sheets from VHGT were read and scored by the investigators. All students got a score referring to a van Hiele level from the VHGT guided by 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)" (1982, p. 22)

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 to determine any differences in terms of performance between the two groups. This t-test procedure showed means score differences in terms of levels between the two groups favoring the control group. Then, scores from the VHGT 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 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' levels between the two groups, ANCOVA was employed to analyze the quantitative data in the study. The pretest scores from the Van Hiele Geometry Test served as the covariate in the analysis of students' levels by curricula and gender effect. ANCOVA enabled the researcher to compare the VHGT scores 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 Van Hiele Geometry Test. 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' attainment of levels for each group. Finally, the researcher constructed frequency tables to get deep information about students' van Hiele levels distributions for both groups.

RESULTS

What differences exist between students who were instructed with a reform - based curriculum and students instructed with a conventional one with reference to the acquisition of the levels in geometry?

Table 1 presents the descriptive statistics and the paired-samples t-test for students' van Hiele levels by the curricula in both the treatment and control groups. According to the paired- samples t-test, the mean score differences between the pre-test and post-test on the VHGT in the treatment group is statistically significant, [$p < .001$, significant at the $\alpha/2 = .025$ using critical value of $t\alpha/2 = -1.96$], and the mean score differences between the pre-test and post-tests on the VHGT in the control group is also statistically significant, [$p < .025$, significant at the $\alpha/2 = .025$ using critical value of $t\alpha/2 = -1.96$]. Based on these statistical test results, one would say that both instructional models either reform-based or traditional have positive effects on the students' acquisition of the levels in geometry.

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, [the mean score of the treatment group is 1.050[a], and the mean score of the control group is .930[a]]. However, the analysis of covariance (ANCOVA) (see Table 2) shows there are no statistically significant differences on the van Hiele levels of students who were instructed with a reform-based curriculum designed on the van Hiele theory compared to students instructed with a conventional one not designed on the van Hiele theory in learning geometry [$F(1, 272) = 2.222$; $p > .05$].

According to Burger & Shaughnessy (1986), the progress through the levels is continuous and not discrete. Despite the fact that students generally are 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 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 mean score .93 of the control group can be explained with the scale described above. The score .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 the previous level, level-0 (Pre-recognition), identified by Clements & Battista (1990), and they have attained 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 that define the 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 reasoning stage in geometry.

Another way to see a difference (again, not statistically significant) 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. Thus, more students in the treatment group progressed from level-0 to level-I than

Table 1. Descriptive Statistics and the Paired-Samples T-Test for Students' van Hiele Levels by Instructional models

Groups	N	Pretest		Posttest			Posttest*	
		M	SD	M	SD	t	M	SE
Treatment	150	.69	.581	1.05	.698	-5.923**	1.05[a]	.05
Control	123	.71	.610	.93	.710	-3.342***	.93[a]	.06
Total	*273*							

Note. a: Evaluated at covariates appeared in the model: Pre- level = .70,
*Estimated Marginal Means.
**$p < .001$, significant at the $\alpha/2 = .025$ using critical value of $t\alpha/2 = -1.96$.
***$p < .025$, significant at the $\alpha/2 = .025$ using critical value of $t\alpha/2 = -1.96$.

Table 2. Summary of ANCOVA for Students' van Hiele Levels by Instructional models

Sources	Sum of Squares	df	Mean Square	F-statistic
Pretest	15.767	1	15.767	35.959
Group	.974	1	.974	2.222

Note. p >.05

Table 3. Frequency Table for Students' van Hiele Levels by Instructional models

Groups	N		Level-0		Level-I		Level-II	
			n	%	n	%	n	%
Treatment	150	Pre- levels	56	37.3	85	56.7	9	6
		Post- levels	26	17.3	98	65.3	26	17.4
Control	123	Pre- levels	46	37.4	67	54.5	10	8.1
		Post- levels	34	27.6	64	52	25	20.4

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

in the control group. Students' progress 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 12.3 % (20.4% - 8.1%) for the control group.

DISCUSSION

Students' Overall van Hiele Levels

None of the sixth-grade students in the study progressed beyond level-II (analysis). Most students' van Hiele geometry levels were level-0 (prerecognition) 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 most 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). 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 with the intended curricula were directed toward level-III geometry knowledge at the end of the geometry instruction, which is an implicit expectation of the students in both groups.

Acquisition of the van Hiele Levels

The paired-samples t-test regarding the attainment of the levels 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 instructional models, whether based on the van Hiele theory or not, have positive impacts on the students' acquisition of the levels 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' attainment between the two groups, however, was not statistically significant. This means that students instructed according to the conventional curriculum for five weeks of instruction in the sixth-grade level on the geometry test matched the reasoning stage of the students instructed with the reform-based curricula.

The National Council of Teachers of Mathematics (NCTM) (2000) 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, research has documented that standards-based curricula (e.g., Connected Mathematics Project, MATH Thematics, University of Chicago School Mathematics Project, Core-Plus Mathematics Project, and Everyday Mathematics) have a more positive effect on students' learning of mathematics more than the more traditional curricula (cf., 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 impact on students' learning to some extent, students did not reach levels expected by the researcher. This is in contrast with the argument stating that the van Hiele theory-based curriculum may be more helpful than the conventional one (e.g., Crowley, 1987). In other words, the finding of this study related to students' growth in terms of levels in geometry did not support Crowley's claim. Clearly, 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 does not resonate 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; Reys et al., 2003).

The finding of the present study, on the other hand, is in accordance with the reports of Reys et al. (2003) who conducted 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 six content strands examined: 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 the same curriculum materials at the eighth grade level. This achievement difference, however, was not statistically significant for geometry learning. They stated, "Students using the NSF Standards-Based curriculum (using the CMP materials) had significantly higher scores than nonusers (not using the CMP materials) on two of the six content Standard scales: Data Analysis, Probability, and Statistics; and Algebra" (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 the present 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 the students' acquisition of geometry knowledge is consistent with their finding. However, the study of Reys et al. (2003) pointed out that students using MATH Thematics curriculum materials, an NSF- funded standards-based curriculum, outscored their counterparts using traditional textbooks in all the six content strands. In other words, in particular students 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 reform-based curricula designed on the van Hiele theory may have shown more gain in learning geometry than their counterparts instructed with a conventional one. Indeed, in this study both instructional models either reform-based or traditional 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, it is prudent to take into account the fact that the teaching-and-learning process can be affected by other factors, such as classroom settings, instructions, parents' support, teachers' help, peers' support, students' interests, learning styles, cognitive competencies, and fear of punishment (e.g., Usiskin, 1982; Burger & Shaughnessy, 1986; 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 the students' acquisition of geometry knowledge. 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 this 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 continuous, 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 the students' attainment of geometry knowledge in mathematics classes. And the students' progress from one level to the next also depends on the quality of instruction more than other factors, such as biological maturation or students' age, environment, parents' support, and peers' support (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 van Hiele levels 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.

Limitation

A student can perform better in one area and yet not show the same performance level in other areas (Fuys et al., 1988; Burger & Shaughnessy, 1986). The geometry topics investigated in the study were polygons and tessellations. The findings of the study could not be applied to all geometry topics. The duration of time given by the schools for the topics to be learned was not enough. Time constraints also pushed the teachers to limit their instruction and 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 of 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. First, most of the students' van Hiele levels 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. Second, both instructional models on either reform-based or traditional had positive impacts on the students' acquisition of the geometry knowledge, but there was no difference between the effects of the curriculums on the students' progress. In other words, students instructed with the reform-based curriculum designed on the van Hiele theory on the geometry test for five weeks at the sixth grade level equaled the progress of the students instructed with a conventional curriculum material.

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