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Reform-Based Curriculum and Motivation in Geometry

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The aim of this study was to compare motivation of sixth-grade students engaged in instruction using 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. This study took place in North Florida. The researchers used a questionnaire, the Course Interest Survey (CIS), administered to the students before and after a five-week of instruction. The paired-samples t-test, the independent-samples t-test, and ANCOVA with $\alpha = 0.05$ were used to analyze the quantitative data. The study showed that there was a statistically significant difference in motivation between the groups favoring the treatment group. In other words, the reform-based curricula designed on the basis of van Hiele theory, compared to a traditional one, had more positive effects on students' overall motivation in learning geometry at the sixth grade level.

Keywords: Curriculum, Motivation, Reform, Middle School, Geometry

INTRODUCTION

Over the past few decades, researchers have documented that many students encounter difficulties and show poor performance in geometry classrooms in both middle and high schools (e.g., Burger & Shaughnessy, 1986; Crowley, 1987; Fuys, Geddes, & Tischler, 1988; Gutierrez, Jaime, & Fortuny, 1991; Mason, 1997; Halat, 2007). Moreover, research shows a decline in students' motivation toward mathematics courses (c.f., Gottfried, Fleming & Gottfried, 2001). Indeed, Ryan & Pintrich (1997), Keller (1998) and Dev (1998) stated that there is a positive correlation between students' performance and motivation in mathematics.

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The longitudinal study of Gottfried et al. (2001) indicated that academic intrinsic motivation declined significantly from middle school through late adolescence in mathematics. 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 revealed that the US fourth graders' achievements 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 level of success as fourth-grade students. Their mathematics performances were at the average level. A decline in the performance of the US students in mathematics between fourth and eighth grades is evident. According to Billstein & Williamson (2003), "declines in positive attitudes toward mathematics are common among students in the middle school years" (p.281). It is important to know what causes students' low performances in mathematics at the middle school level.

Variables Affecting Students' Motivation

Research has documented that there are many internal and external factors, such as feeling valued, perception of cognitive competence, benefits and threats from peers and teachers, perception of parents' support, perception of success, fear of punishment, environment, task difficulty, real-life activities, instruction, and gender that appear to play prominent roles in students' motivation in mathematics classes (e.g., Reeve, 1986; Driscoll, 1994; Wentzel, 1997/1998; Stipek, 1998; Middleton, 1999; Alderman, 1999; Halat, 2006). For instance, Middleton & Spanis (1999) state that students' perception of success in mathematics has a great effect on students' motivational attitudes. Wentzel (1998) posits that parents' support, peers' help and teachers' care are vital factors playing important roles in students' learning. However, Stipek (1998) claims that teachers have more influence on students' motivation in learning mathematics than parents do 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 are willing to engage in classroom activities and highly motivated to be successful in the mathematics class (Wentzel, 1997).

According to Usiskin (1982), many students fail to grasp key concepts in geometry, and leave the 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 impacts on students' achievement 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 (Hoffer, 1986; Messick & Reynolds, 1992).

Messick & Reynolds (1992) state that the students in any given classes may show variation in interests, capabilities, and intelligences. In response to this variation, the instructors should show different ways for students to succeed based on their learning styles. Furthermore, carefully structured instructional design including clear and meaningful task activities and level of difficulty have a great impact on students' achievement and motivation in mathematics, Stipek (1998) and Middleton & Spanis (1999).

The Van Hiele Theory

Knowledge of theoretical principles provides an opportunity to devise practices that have a greater possibility of success. 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; 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 several geometry 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. In other words, several researchers (e.g. Usiskin (1982), Mayberry (1983), and Burger & Shaughnessy (1986)) confirmed the validity of the levels and investigated students' behavior on tasks. Others (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. Moreover, there have been some studies with pre-service elementary and secondary mathematics teachers regarding their reasoning stages in geometry (e.g., Mayberry, 1983). Surprisingly, these studies have found that many of the prospective mathematics teachers do not attain an appropriate level of geometry knowledge they are expected to teach.

Purpose of the Study

The aim of this current study was to compare motivation of sixth - grade students engaged in instruction using a reform-based curriculum with sixth-grade students engaged in instruction using a traditional curriculum. This study addresses "the need . . . for classroom teachers and researchers to refine the phases of learning, develop van Hiele theory based materials, and implement those materials and philosophies in the classroom setting" (Crowley, 1987, p.15). The instruction following the reform-based curriculum designed on the basis of van Hiele theory used the textbooks *Shapes and Designs* (Lappan, Fey, Fitzgerald, Friel, & Phillips, 1996); and *Discovering Geometry: An Inductive Approach* (Serra, 1997). The comparative group's instruction used *Middle School Math Course I* (Charles, Dossey, Leinwand, Seeley, & Embse, 1998). The following question guided the study.

Question: What differences, if any, exist with respect to motivation between students instructed with a reform-based curriculum and students instructed with a conventional one in geometry?

The researchers agree with the recommendation of NCTM (2000) that educational theories and approaches be used in teaching and learning to help students overcome their difficulties in mathematics. In addition, knowledge of theoretical principles gives teachers an opportunity to devise practices that have a greater possibility of success (e.g., Swafford, Jones, & Thornton, 1997). Furthermore, standards-based curricula have positive influences on students' performance and motivation in mathematics (e.g., Billstein & Williamson, 2003; Chapell, 2003).

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

In the study the procedure of quasi-experimental design was used. With this design technique, the researchers 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 posttest, and only the experimental group receives the treatment" (Creswell, 1994, p.132).

The researchers 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-posttests were given to the students before and after the instruction. The researchers investigated the effects of an instruction using a reform-based curriculum on students' motivation in learning polygons in geometry. The comparison of students' motivational levels was made. Therefore, this experimental approach enabled the researchers to evaluate the effectiveness of an instruction that uses the reform-based curriculum with the results of a questionnaire in mathematics classroom.

Participants

In this study the researchers 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 Florida. The researchers chose these two schools based on their curriculum practices and permissions of the schools' principals. One of the schools was following a reform-based curriculum, and the other one was not using a reform-based curriculum in their geometry teaching. There were a total of 273 sixth- grade mathematics students, 123 in the control group and 150 in the treatment group, involved in the study. The majority of the students in both schools were from families of low socio-economic class. Almost 80 percent of the students involved in the study were eligible for the federal free or reduced-price lunch program as reported by the state. This percentage is considered to be a major indication of the students' family income level.

Data Sources

The data collection process began with giving students a questionnaire, *Course Interest Survey (CIS)*. This questionnaire used as pre-and-posttests in the study was administered to the participants during a single class period by the researchers before and after the five-week instruction period. The questionnaire *Course Interest Survey (CIS)* consists of 34 statements categorized into four parts, Attention, Relevance, Confidence and Satisfaction. Using a liker-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) 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, students in both groups met for an hour of instruction in a day for five days a week.

Instructional Curricula

The instruction following the reform-based materials used a curriculum designed on the basis of van Hiele theory. This curriculum used the textbook *Shapes and Designs* and *Discovering Geometry: An Inductive Approach* in which 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 reform-based materials used the textbook *Middle School Math Course I* that also covers material at the first three van Hiele levels.

Topics in both curricula consisted of polygons, such as triangles and quadrilaterals, properties of the figures, angle relations and transformation and tessellation.

There were four mathematics teachers involved in the study, all of whom were females. Both mathematics teachers in the treatment group attended the Connected Mathematics Project's (CMP) training programs. They both implemented the CMP's instructional model: "launch, explore and summarize" in their teaching that is problem-centered teaching opens the mathematics classroom to exploring, conjecturing, reasoning, and communicating.

This model of instruction involves three main phases. In the *launch* phase the teacher introduces the problem to the class. The teacher makes sure that students understand the problem and are engaged in it. It is important that problems be interesting and make connections with earlier concepts in mathematics or with past experiences of students. It is also an opportunity for the teacher to introduce a new idea.

In the *explore* phase students work on the task individually, in small groups or occasionally as a whole class. The students work on the problem by searching for patterns, gathering data, trying special cases, making conjectures, and exchanging ideas; and the teacher moves around the classroom, observing students' work and offering help as appropriate. The teacher provides encouragement and confirmation to on-track behavior, and may ask guiding questions and offer redirections when needed. He or she may also offer additional challenges for those students who quickly solve the problem or may not find it challenging enough.

The *summarize* phase begins when most students make sufficient progress towards a solution to the problem. Students discuss their solutions and share their strategies they used to reach a solution. They will appreciate other approaches to the problem, and can see ways to enhance their own strategies. The teacher also offers guidance and suggestions for a deeper understanding of the concepts and more effective and efficient problem solving strategies (e.g., Lappan, Fey, Fitzgerald, Friel, & Phillips, 1996; Reys, Reys, Lappan, Holliday, & Wasman, 2003).

One of these teachers had 15 and the other had 4 years of teaching experience. On the other hand, the mathematics teachers in the control group followed the traditional way of teaching. In other words, the mathematics teachers told the students facts, demonstrated procedures, showed how to solve the problems and then students memorized the facts and practiced the procedures. One of these teachers had 14 and the other had 5 years of teaching experience.

Test Scoring

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 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.

Analysis of Data

The data were responses from students' answer sheets. First the researchers run the independent-samples t-test statistical procedure with $\alpha = .05$ on the students' pretest scores to see if there exist any initial differences on students' motivation levels between the two groups. The t-test procedure showed mean score differences between the two groups favoring the control group on students' motivation. Then, scores from the questionnaire (CIS) were compared using one-way analysis of covariance (ANCOVA) with $\alpha = 0.05$, which is a variation of ANOVA. The ANCOVA was used to adjust for pretest differences that exist between control and treatment groups. In other words, because of the initial differences in students' motivational levels between the two groups, ANCOVA was employed to analyze the quantitative data in the study. The pretest motivation scores from the Course Interest Survey served as the covariate in the motivation analysis by curricula. ANCOVA enabled the researchers to see the results of comparisons of CIS scores.

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 questionnaire. 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 researchers see the effects of each curriculum on students' motivation for each group.

RESULT

Question: What differences, if any, exist with respect to motivation between students instructed with a reform-based curriculum and students instructed with a conventional one in geometry?

Table 1 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 1), the mean score differences in terms of motivation between the pre-and posttests on the CIS in the treatment group is statistically significant, [$p < .001$, significant at the $\alpha/2 = .025$ using critical value of $t_{\alpha/2} = -1.960$], and the mean score differences in motivation between the pre-and posttests on the CIS in the control group is also statistically significant, [$p < .025$, significant at the $\alpha/2 = .025$ using critical value of $t_{\alpha/2} = -1.960$]. In other words, both curricula, whether reform-based or not, positively impacted students' motivation in the study.

Table 2, 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 that a significant main effect for students' motivation toward a reform-based curriculum was obtained, [$F(1, 272) = 5.660$; $p < .05$]. Furthermore, Table 1 indicates that students instructed with a reform-

Table 1. Descriptive Statistics and the Paired-Samples T-Test for Students' Motivation Based on the CIS Scores by Curricula

Groups	N	Pretest		Posttest			Posttest*	
		M	SD	M	SD	t	M	SE
Treatment	150	119.81	15.3	129.53	14.0	-11.738**	132.042[a]	.7
Control	123	127.48	17.6	132.32	16.3	-5.034**	129.257[a]	.8
Total	273							

Note. a: Evaluated at covariates appeared in the model: Pre-motivation =123.26, *Estimated Marginal Means, CIS: Course Interest Survey. ** $p < .001$, significant at the $\alpha/2 = .025$ using critical value of $t\alpha/2 = -1.960$.

Table 2. Summary of ANCOVA for Students' Motivation Based on the CIS Scores by Curricula

Sources	Sum of Squares	df	Mean Square	F-statistic
Pretest	38450.674	1	38450.674	437.800
Group	497.139	1	497.139	5.660

Note. $\alpha = .05$, $p < .05$, CIS: Course Interest Survey.

Table 3. Frequency Table for Students' overall Motivation Based on the CIS Scores by Curricula

Groups	N		Low*		Average**		High***	
			n	%	n	%	n	%
Treatment	150	Pre-motivation	15	10	104	69.3	31	20.7
		Post-motivation	1	0.7	92	61.3	57	38
Control	123	Pre-motivation	12	9.8	59	48	52	42.2
		Post-motivation	4	3.2	58	47.2	60	48.6

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.

based curriculum outscored the ones who were instructed with a traditional 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 3 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 3). Table 3 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 researchers 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.

In summary, the ANCOVA indicated a statistically significant difference in students' motivation toward the reform-based curricula.

DISCUSSION

Students' Motivation

The question of this study was pertinent to whether there exist any differences in terms of motivation between students instructed with reform-based curriculum and a traditional one. Students exposed to reform-based curricula showed a greater motivational performance level in learning geometry in the sixth grade than the ones exposed to the conventional one. This finding does not support the claims of Eccles & Midlegy (1989), and Gottfried, Fleming, & Gotfried (2001) that there is a decline in students' motivation toward mathematics courses.

A number of variables, such as teaching method, socio-economic level, environment, parental support, task difficulty, teacher-care, curriculum, success, peer support, and others are vital in students' learning, but in general students' learning is more affected by instruction than other factors (i.e., Fuys, Geddes & Tischler, 1988; Stipek, 1998). For instance, Wentzel (1998) found 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 are primarily additive rather than compensatory. This is in line 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). Students who feel supported and valued by their teachers are willing to engage in classroom activities and highly motivated to be successful in the mathematics classes (Wentzel, 1997).

Many of the important factors affecting motivation were similar between the two groups in the study, except for the method of instruction. All teachers were females with similar amount of teaching experiences. The students in both groups were from low income families as described in the methodology part. The major difference between the two groups in the study was the curriculum practice in terms of variables affecting motivation. The mathematics teachers in the treatment group implemented reform-based geometry curriculum with its own instructional model: launch, explore and summarize (e.g., Reys, Reys, Lapan, Holliday, & Wasman, 2003). Real-life examples or activities were major motivating factors in the reform-based mathematics classrooms. According to Middleton (1995), teachers believe that using real-life applications, group practices, hands-on activities, and other strategies play important roles in students' motivation.

Although each one of the variables mentioned above has an impact on students' motivation in learning geometry, the instruction strongly influenced by the curriculum has more effect on students' performance and motivation in the mathematics classes than others (e.g., Stipek, 1988; Driscoll, 1994; Wentzel, 1997; Middleton & Spainas, 1999; Reys et al., 2003). In this study, the reform-based curriculum based on the van Hiele theory made a more positive impact on students' overall motivation in learning geometry at the sixth grade level.

IMPLICATION & LIMITATION

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

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; Halat, 2006). Therefore, the reform-based curricula designed on the basis of van Hiele theory may help students enhance their motivation in geometry.

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). The geometry topics investigated in the study were polygons and tessellations. Therefore, the findings of the study may not necessarily be applicable to all geometry topics. Also, the amount of time allotted by the schools for the topics to be covered was likely inadequate. Time constraints pushed the teachers to limit their instructions 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. Romberg & Shafer (2003) assert that the instructional experiences affect students' learning mathematics with understanding (p.245). In addition, the vast majority of the students were from low income families. Therefore, these findings should not be assumed to automatically generalize to students from other socio-economic backgrounds.

Future Research

The current study investigated the effectiveness of the reform-based curricula on students' motivation in learning geometry at the sixth grade level in a few particular topics. Learning is a very complex process affected by many factors. This study examined one of the important factors, namely method of instruction in sixth grade geometry. The effects of many of the other independent variables on students' learning of geometry may be investigated and their interactions could be examined in order to get an in-depth information and help students enhance their knowledge of geometry. Also, it would be interesting to examine if similar results are obtained with different topics and at different grade levels.

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