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Abstract

In this research study, I investigated the relationships between preferences for solution methods, task difficulty, gender, and high school students' geometry performance. Data were collected from 161 geometry students at six high schools at a county located in the southeastern region of the USA at the time of the 2013–2014 school year. The result revealed that there was not an association between preference for solution methods and geometry performance. The majority of students demonstrated a preference for visual solution methods. However, the preference for visual or nonvisual methods was not associated with task difficulty. That is, students were equally likely to employ visual as well as nonvisual solution methods regardless of the task difficulty. The study further revealed that there was a significant difference between male and female students in geometry performance but not in preferences for solution methods. Females outperformed males in geometry performance. The data analysis also indicated that the majority of students were visualizers.

Introduction

The factors underlying differences in mathematical performance have been of great interest for researchers for many decades. There are few research studies that have attempted to analyze the relationship between preferences for solution methods, geometry performance, and gender. Even fewer studies have attempted to study the association between geometry task difficulty and preference for solution methods. However, the related research studies indicated inconclusive findings in this area (Lowrie, 2001; Lowrie & Kay, 2001). In-depth knowledge about what kind of solution methods students prefer to use and what difficulties they encounter when solving geometry tasks, and relationships between gender and geometry performance can contribute to the theoretical as well as practical knowledge in the domain of mathematics teaching and learning. Moreover, how students prefer to solve mathematics problems has an important implication in educational theory and practice (Stenberg & Grigorenko, 1997). Thus, this study sought to examine the relationships between preferences for solution methods, task difficulty, gender, and high school students' geometry performance.

In the domain of mathematics, students prefer to use two modes of processing mathematical information (modes of thought): verbal-logical and visual-pictorial (Krutetskii, 1976). The preferred mode of processing refers to how students prefer to process information, not whether they possess particular skills or abilities (Haciomeroglu, Chicken, & Dixon, 2013). Students attempt to solve mathematical tasks or learn mathematics with the aid of formulae, logical reasoning, and so forth, without using the visual images in the verbal-logical mode of thought, whereas they process mathematical information based on visual images in the visual-pictorial mode of thought. Students can be divided into three groups: visualizers, nonvisualizers, and harmonic based on two types of modes of processing mathematical information. Visual students use visual solution methods and nonvisualizer students use nonvisual solution methods, whereas harmonic students use both visual and nonvisual solution methods. Students use diagrams and figures in their head while attempting mathematical tasks in a visual solution method. The diagrams and figures play a dominant role in a visual solution method. In a nonvisual solution method, students use mathematical formulae, rules, axioms, postulates, numbers, equations etc., while attempting mathematical tasks. The extent which students use a visual or nonvisual solution method is also called visuality. Thus, visuality refers to the extent to which the students use visual solution methods to solve given mathematical problems.

Theoretical Framework

Students prefer to solve mathematics problems using different solution methods. Students who prefer to use visual solution methods are called visualizers, whereas students who use nonvisual solution methods are called nonvisualizers. Harmonic students employ both visual and nonvisual solution methods. In this regard, Krutetskii (1976) conducted comprehensive studies to describe mathematically gifted students' abilities and preferences. According to Krutetskii, students can be divided into visualizers, nonvisulizers, and harmonic based on two preferred mode of processing mathematical information: visual-pictorial and verbal-logical.

Students attempt to solve mathematical tasks or learn mathematics with the aid of formulae, logical reasoning, and so forth, without using the visual images in the verbal-logical mode of thought, whereas they process mathematical information based on visual images in the visual-pictorial mode of thought. Visualizer students use visual solution methods and nonvisualizer students use nonvisual solution methods, whereas harmonic students use both visual and nonvisual solution methods. A solution method in which students employ diagrams and figures, or draw diagrams and figures, or visualize diagrams and figures in their mind while attempting mathematical tasks. The diagrams and figures play a dominant role while attempting mathematical tasks. In a nonvisual solution method, students use mathematical formulae, rules, axioms, postulates etc., while attempting mathematical tasks.

Krutetskii further suggests that the levels of mathematical giftedness are determined by the level of development of each mode of mathematical thinking and by the interrelation between modes of thought. Based on the correlation between verbal-logical and visual-pictorial components, different structures of mathematical abilities and casts of mind are formed for successful mathematical performance. In fact, the *levels* of mathematical abilities are largely determined by a verbal-logical component, while the *types* of mathematical giftedness are determined largely by a visual-pictorial component. He claimed that the visual-pictorial component determines the type of a student's mathematical ability but not its level. Krutetskii also reported several cases of students who were very capable in mathematics but had very weak visual-pictorial components. Since there is a relationship between mathematical performance and preference for solution methods, the preference for solution methods might underlie differences in mathematics learning (Haceiomeroglu & Chicken, 2011).

Following the work of Krutetskii, Moses (1977) also placed students on a continuum with regard to their preference for solution methods for solving mathematical problems. Students belong to one of the three categories: (a) nonvisualizers: students who have a preference for manipulating words, sentences, algebraic and numeric representation, (b) visualizers: students who have preference for manipulating images, drawings, constructions or any other visual representations, and (c) harmonic: students who have a preference for using both visual and nonvisual solution methods equally. The nonvisualizers operate mathematical concepts and ideas easily with abstract schemes without having to visualize objects or patterns in problem solving, even when a given mathematical task demands visual schemes. These students always attempt to employ verbal-logical processing or verbal-logical methods. However, the nonvisulizers attempt mathematical tasks with the aid of graphic representations.

Mathematics, especially geometry, is based on the system of representation. Students employ different types of modes of representation while attempting mathematics problems. Whether students are verbalizers or visualizers, they need representation to solve mathematics problems. Representation is classified in various categories based on nature, attributes, and modes. Janvier (1987) proposed four modes of representation: (a) verbal descriptive, (b) tabular, (c) graphic, and (d) formulaic (equation); however, four modes of representations: graphic, numeric, algebraic, and verbal are common in mathematics teaching and learning.

Algebraic, numeric, and verbal representation are associated with nonvisual solution methods, whereas graphic representation is linked with visual solution methods. Students constantly change the representations while solving mathematics problems. Thus, they translate one representation to another based on their preferences for solution methods (Lesh, Post, & Behr, 1987). Most researchers agree that translation ability is very important for learning and problem solving in mathematics because translation of one mode of representation to another will provide flexibility to problem solvers while attempting mathematics problems (Doufour-Janvier, Bednarz, & Belanger, 1987; Gagatsis & Shiakalli, 2004; Hitt, 1998; Janvier, 1987; Lesh, Post, & Behr, 1987).

Background

Preferences, Performance, and Task Difficulty

Moses (1977) and Suwarsono (1982) examined preferences for solution methods and mathematical performance and reported no association between preferences for solution method and mathematical performance. In a similar study, Pitta-Pantazi and Christou (2009) also found that there is no relationship between preferences for solution methods and mathematical achievement. Battista (1990) reported that preferences for solution methods were not significantly correlated to geometry performance. However, preferences for nonvisual solution methods were positively correlated with geometry performance only for male students.

A study conducted with engineering college students by Lean and Clements (1981) reported that preferences for solution methods had significant influence on students' mathematical performance. Their study further revealed that students who employed nonvisual solution methods performed significantly better than the students who employed visual solution methods. In consistent with Lean and Clements, Galindo (1994) reported that students who were nonvisulizers obtained significantly higher scores than visualizers in the calculus section with and without the use of technology; however, there was not a significant relationship between preferences for solution methods and calculus performance using graphing calculators. However, their findings conflicted with Webb (1979), who reported that students who preferred to use visual solution methods tend to outperform those who use less visual solution methods. Lowrie and Kay (2001) and Hegarty and Kozhevnikov (1999) also reported that preferences for visual solution methods were positively correlated with mathematical performance.

Haciomeroglu, Aspinwall, and Presmeg (2009) developed cases describing two students' preference for solution methods and calculus performance. They reported that students over relied on visual processing experienced difficulties and was not able to complete the derivative tasks presented graphically. This study supported the Krutetskii (1976) thesis that regardless of the mode of representation used to present a problem, students were equally likely to use both visual and nonvisual solution methods. Haciomeroglu, Aspinwall, and Presmeg (2010) further reported that both visual and nonvisual solution methods are essential components for successful mathematical performance. In another similar study, Haciomeroglu, Chicken, and Dixon (2013) reported that the preferences for visual solution methods were significantly correlated with calculus performance, which was not consistent with findings from Moses (1977), Lean and Clements (1981) and Suwarsono's (1982). Their study also revealed that visualizers and harmonics did not differ significantly with respect to their calculus scores but the nonvisulizers had significantly lower calculus scores than the other two groups.

Haciomeroglu and Chicken (2011) further revealed that students' preferences for solution methods were positively correlated with calculus performance, where the problems were presented graphically; however, the preferences were not associated with calculus performance, where the tasks were presented algebraically. Guay and McDaniel (1977), Calvin, Farnandes, Smith, Visscher, and Deary (2010) also did not find any interaction between preference for solution methods and calculus performance. However, Kolloffel (2012) reported that despite the differing teaching strategies used, no correlation was observed between preferences for solution methods and mathematical performance. As this research study was aimed particularly for students' geometry performance and preferences for solution methods, a search of the related literature in this domain indicated that it is likely that no research studies have been published in this area.

There are few research studies that have been conducted to examine preference for solution methods and task difficulty. Lowrie and Kay (2001) reported that task difficulty had a major influence on the way students solved mathematics problems. Students preferred to use visual solution methods than nonvisual solution methods to solve the difficult tasks. In contrast to Lowrie and Kay, Lowrie (2001) reported that there was not a significant correlation between the preferences for solution methods and task difficulty.

Similar to Lowrie and Kay (2001), Haciomeroglu (2012) reported that as task difficulty level increased, the number of visual solution methods (correct and incorrect) increased significantly, and the number of nonvisual methods decreased significantly for the graphic representation. For the algebraic problems, students used more nonvisual methods than visual method. However, as the level of problem difficulty increased, the number of nonvisual solution methods was significantly decreased, while the visual methods were substantially increased. Gorgorio (1998) also reported that students' preferences for solution methods depend on task difficulty and interpretation of the given task and construction of new objects. The study further revealed that when students' were required to interpret objects, they tended to use visual solution methods for a simple object; however, when the object was complex, students used nonvisual solution methods. They further argued that when students need to construct new objects, students tended to use visual solution methods when an object was complex and use nonvisual solution methods when an object was simple.

Gender Differences in Mathematics

The relationship between gender and mathematical performance has been of great interest to researchers for many decades. Numerous research studies were conducted in this field, and the results revealed that male students outperform female students (Battista, 1990; Fennema, 1974; Fennema & Sherman, 1978; Guay & McDaniel, 1977; Maccoby & Jacklin, 1974; Matteucci & Mignani, 2011). However, other research studies that have been done in this area also assert that mathematical performance is independent to gender (Galindo, 1994; Haciomeroglu & Chicken, 2012). Thus, there are no conclusive findings regarding gender difference in mathematical performance.
A study conducted by Fennema and Sherman (1978) reported that there was no significant difference between males and females students in mathematical performance. However, in another similar study, Fennama and Tartre (1985) found that male students solved more problems correctly than female students. Fennema and Carpenter (1981) reported that males significantly outperformed females in the area of geometry. This study also reported that there was no significant difference in mathematical performance between male and female students ages 9 and 13; however, there was a significant difference in mathematics achievement of 17-year-old students favoring males.

Battista (1990) conducted a study to examine high school students' gender and geometry performance and reported that male students scored significantly higher than female students on a geometry problem-solving test. However, Haciomeroglu and Chicken (2012) reported that students' gender did not have a significant effect on their preferences for visual or analytic thinking. Galindo (1994) also noted no significant sex-related difference in calculus performance of college students. Guay and McDaniel (1977), Calvin, Farnandes, Smith, Visscher, and Deary (2010) also did not find interaction between gender and calculus performance. Fennema and Sherman (1978) investigated sex-related differences in mathematics and related factors with middle school students. They reported that there was no significant difference between male and female students in terms of mathematical performance. Fennama and Tartre (1985), however, found that male students solved more problems correctly than female students.

Gallagher and De Lisi (1994) reported that male and female students did not differ in all mathematical performances; however, gender difference was significant for conventional problems but was not significant for unconventional problems. Female students used conventional strategies significantly more often than male students and male students used unconventional strategies significantly more often than female students. Following the Gallagher and De Lisi (1994) study, Gallagher, De Lisi, Holst, McGillicuddy-De Lisi, Morely, and Cahalan (2000) reported that in multiple-choice conditions, female students were more successful with conventional problems than with unconventional problems; however, in free response conditions male students were more successful with conventional problems than unconventional problems. Female students' performance was lower than male students' performance on conventional problems. Fennema and Carpenter (1981), however, reported that males significantly outperformed females in the area of geometry.

Fennema, Carpenter, Jacobs, Franke, and Levi (1998) examined gender differences in young children's mathematical performance focused on operations of basic fact of numbers and reported that no gender difference in solving number fact, addition/subtraction, or nonroutine problems; however, gender differences were noted in solution strategies. Girls tended to use more concrete strategies such as counting and boys tended to use more abstract strategies, which was consistent with findings of Gallagher and De Lisi (1994). Similarly, a meta-analysis conducted on gender differences by Hyde, Fennema, and Lamon (1990) reported that there was no gender difference in arithmetic or algebra performance; however, males' geometry performance was slightly higher than females' geometry performance. Similarly, a meta-analysis conducted on gender differences by Hyde, Fennema, and Lamon (1990) reported that there was no gender difference in arithmetic or algebra; however, males' geometry performance was slightly higher than females' geometry performance.

Statement of the Problem

The related literatures suggest that findings about the relationship between preferences, task difficulty, gender, and mathematical performance are inconclusive. Thus, this study aims to examine only students' preferences for solution methods in the domain of high school geometry. The following research questions were investigated in the present study:

1. Are preferences for solution methods associated with high school students' geometry performance?
2. Are the degrees of difficulty of geometry tasks associated with students' preference for solution methods?
3. Do males and females differ in preference for solution methods and geometry performance?

Methodology

Participants

The data were collected from high schools at a county located in southeastern region of the USA at the time of study. The sample consisted of 161 geometry students whose ages ranged from 14 to 19 years. Approximately 41% of the students were male, and 59% were female. Participants also consisted of various ethnicities. Of the students, 24% were White, 37% Hispanic, 26% African American, 2.5% Asian or Pacific Islander, and 6.8% Multiracial. A total of 6.8 % of the participants were between the ages of 14 and 15, 54% were between the ages of 16 and 17, and 38% were 18 and above. Eight teachers were involved from six different schools.

Research Instrument and Data Collection

A geometry test and a corresponding questionnaire were used to collect data in regular classroom during school time. The geometry test consists of 12 questions from different topics of high school geometry. The geometry problems were different in regards to the complexity level: some were easy while other were difficult. The corresponding questionnaire contains different types of solution methods for each problem on the geometry test. Upon completion of the geometry test, students were given the geometry questionnaire and asked to choose the solution methods from the list that best described the solution methods they employed to complete geometry problems.

Results

For the purpose of statistical analysis, students' preferences for solution methods were quantified into numeric values. Students were given a score one for each visual solution method and score of -1 for each nonvisual solution method. A score of zero (0) was given if students did not choose their solution methods, chose both solution methods, or could not determine the solution methods they used. Thus, for 12 problems, a student could obtain a score ranging from -12 to +12. The mean visuality score for each problem was calculated by dividing the sums of the scores by total number of students. The descriptive statistics regarding the visuality is given in the following table 1.

Table 1. Descriptive statistics of visuality for each problem

Problems	*Visual solution (%)*	*Nonvisual solution (%)*	*Mean visuality score*
1	84.47	11.1	.74
2	81.36	10.55	.71
3	76.39	13.66	.63
4	62.11	28.57	.34
5	81.36	12.42	.70
6	75.15	17.39	.58
7	72.04	14.28	.58
8	43.47	47.88	-.02
9	62.73	18.63	.46
10	67.08	22.36	.43
11	77.08	7.45	.70
12	70.18	11.18	.60

The difficulty level of each problem in the geometry task was determined by how many students were able to solve the geometry problems correctly as well as the researcher's knowledge and experience of teaching and learning mathematics. The more the participants able to solve the task correctly, the easier the problem would be. For example, 26% of the total participants were able to solve the problem one correctly, while only 6.8% of participants were able to solve the problem two correctly. Thus, the problem number one was deemed easier than the problem number two. The task difficulty has given in the table 2.

Table 2. Task difficulty of the geometry test

Problems	1	2	3	4	5	6	7	8	9	10	11	12
Correct (%)	26	6.8	15.5	7.4	7.4	9.3	8	37.8	33.5	28	37.8	7.4

Analysis of students' work revealed that the problems 1, 8, 9, 10, and 11 were categorized as easy tasks, and the problems 2, 3, 4, 5, 6, 7, and 12 seemed to be relatively difficult tasks. In fact, the difficulty level of geometry task did not fall into three categories: easy, medium, and difficult as it was anticipated when the test was designed and developed.

The students' score on the End of Course (EoC) exam used as a measure of students' geometry performance. The EoC is a standardized assessment administered in the state where the research conducted. EoC assessment for geometry is designed to measure students' content knowledge and skills in three areas of geometry: two-dimensional geometry, three-dimensional geometry, and trigonometry and discrete mathematics. EoC is timed standardized test administered via computer. EoC is valid and reliable assessment (Florida Department of Education, 2015). Regardless of students' enrollment in different types of geometry courses with different ages in high school, there was only a single EoC assessment for all students.

We recorded how many geometry problems students answered correctly and incorrectly. The type of solution methods for each participant was also recorded. The geometry test and the geometry questionnaire were analyzed at the same time for every participant to ensure the accuracy between the actual solution methods they used to solve the problems and solution method they chose in the geometry questionnaire. Example of visual and nonvisual solution methods from students' work are presented below:

PROBLEM 10

Find the distance between the points *P* (−6,1) and Q (2,1).

.

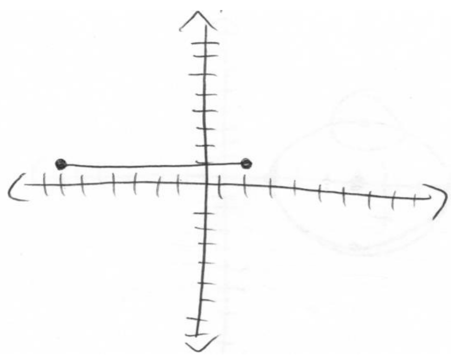

Figure 1. A visual solution of method for the problem Ten

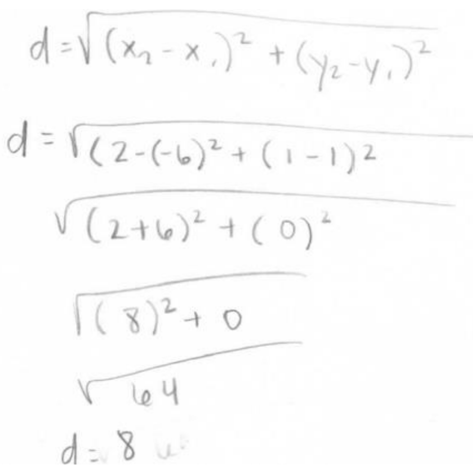

Figure 2. A nonvisual solution method for problem the Ten

A simple regression analysis was used to test the association between preferences for solution methods and students' geometry performance in which visuality score was a dependent variable. The results of the regression analysis indicated that preference for solution methods did not correlate with students' geometry performance (R^2 = 0.01, *F*= 1.70, *df* = 1,159, *p* > 0.05). Table 3 and 4 illustrate the summary of the regression analysis.

Table 3. Correlation matrix

		Visuality	Performance
Pearson Correlation	Visuality	1.000	.103
	Performance	.103	1.000
Sig. (1-tailed)	Visuality	.	.097
	Performance	.097	.
N	Visuality	161	161
	Performance	161	161

Table 4. Regression model summary of preference and performance

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.103[a]	.011	.004	11.070

The difficulty level of geometry task did not fall into three categories: easy, medium, and difficult as it was anticipated when the test was designed and developed. The researcher, therefore, divided problems into three categories; rather, used the degree of difficulty, as it was they appeared when students solved problems. Preferences and degree of difficulties were the two variables. The association between task difficulty and preference for solution methods was examined using a Pearson's product-moment correlation coefficient. The analysis indicated that there was not a significant correlation between task difficulty and preference for solution methods (*r* = -.385 *n* =12, *p* > .05). The summary of the analysis is shown in Table 5. The negative correlation, however, suggested that as task difficulty increases the visuality decreases, which implies that students tend to use visual solution methods for more difficult task.

Table 5. Summary of correlation analysis

		Visuality	Difficulty
Visuality	Pearson Correlation	1	-.385
	Sig. (2-tailed)		.216
	N	12	12
Difficulty	Pearson Correlation	-.385	1
	Sig. (2-tailed)	.216	
	N	12	12

A Multivariate Analysis of Variance (MANOVA) was used to compare males and females' preference for solution methods (visuality) and their geometry performance. Gender was the independent variable, whereas students' preference for solution methods and geometry performance were the two dependent variables. MANOVA is required to satisfy certain assumptions. Therefore, multivariate normality, linearity, and homoscedasticity were checked before conducting the test. Homoscedasticity is the assumption that variability in scores for one continuous dependent variable is roughly the same at all values of another continuous variable. Box's M test of equality of variance-covariance matrices was used to assess the homoscedasticity. Since the homoscedasticity assumption was not satisfied and group sample sizes were unequal, Pillai's Trace was used for further analysis. The statistical analysis showed that gender was significant in determining the combined test results in preference for solution methods and geometry performance (*F* (2,158) = 7.985, *p* < .001, Pillai's Trace = .092). The test between-subject effects indicated that gender was significant factor in geometry performance (F_1 (2,158) =15.895, *p* < 0.001, η^2 = 0.091) but not significant in preference for solution methods (F_2 (2,158) =

0.00, $\eta^2 = 0.00$, $p > .05$). To investigate further the gender differences in geometry performance, an independent sample *t* test was conducted. The independent *t* test indicated that geometry performance was statistically significantly different (t (115.10) = -3.80, $p < .001$) between male and female students. Female students' geometry performance (M = 49.98, SD = 9.32) was significantly higher than male students' geometry performance (M = 43.20, SD = 12.33). The effect size was measured by using Cohen's *d*. The effect size was 0.623, implying a medium effect size.

Discussion

This study revealed that preference for solution methods did not correlate with students' geometry performance, which is consistent with several other research studies. Similarly, there was not a significant correlation between task difficulty and preference for solution methods. Gender was a significant factor in geometry performance but not in preference for solution methods and female outperformed males. We believe that there are mainly three factors: the geometry tasks, the representation used to present the geometry problems, and nature of math content that have been used to conduct the study might have contributed to support as well as contradicted various other similar studies.

Despite the relationships between preference for solution methods and mathematical performance reported by several studies' (Battista, 1990; Bremigan, 2005; Ferrini-Mundy, 1987; Haciomeroglu, Chicken, & Dixon, 2013), this study revealed that the preference for solution methods did not correlate with geometry performance. This is consistent with several previous research studies (Galindo, 1994; Hegarty & Kozhevnikov, 1999; Lowrie, 2001; Moses, 1977; Suwarsono, 1982). There can be several explanations for differences in the results of these studies. One explanation for the inconsistency is the use of different types representations to present mathematical tasks to measure students' preference for solution methods. More than a half of the geometry problems were presented using visual representations for example in Battista's instrument; however, in this study, of the 12 tasks on the geometry packet, 11 tasks were presented verbally. Thus, I think that inconsistency in the result involved the use of representations to present geometry problems. Moreover, results are inconsistent because these researchers used different tasks (algebra, geometry or calculus). Furthermore, combination of representations and mathematics-content area might also have contributed in the inconsistency. Bremigan (2005) focused on calculus emphasizing the role of visual representation, Ferrini-Mundy (1987) and Haciomeroglu, Chicken, and Dixon (2013) focused on calculus using graphic representation. However, verbal representation was used to design the high school geometry test. The representations employed as well as mathematics content areas vary greatly among these studies.

Similarly another explanation for the inconsistency can be the type of test used to measure students' preference for solution methods and performance. For example, Calculus problems may need more sketching and graphing, algebraic problems may require more computational work, and geometry problems might need more figures. Thus, the instruments used to measure students' mathematics performance varied greatly. This research study used a geometry test, a geometry questionnaire, and students' geometry End-of-Course (EOC) scores, Galindo used the modified version of Suwarsono Mathematical Processing Instrument (MPI), Haciomeroglu, Chicken, and Dixon used AP calculus score, and Gallagher and De Lisi (1994) used SAT score. Thus, the different types of test instruments could have supported or contradicted the findings of this study with other studies.

This study revealed that there was not a significant correlation between task difficulty and preference for solution methods; however, this was not consistent with the findings of Lowrie and Kay (2001) and Haciomeroglu (2012) but consistent with Lowrie's (2001) finding. The descriptive statistics showed that the geometry test appeared to be difficult for students because the majority of them were not able to solve the problems correctly. Students were allowed to use a formula sheet in EoC exam; however, they were not permitted to use formula sheet for the geometry test, which might be one of the reasons that might have affected their preferences. Only 38% of the participants were able to give correct answer for the less difficult questions, whereas only 8% were able to provide correct answer for the difficult questions. Thus, the set of difficult problems might not have captured students' actual preferences for solution methods and contradicts with Lowrie and Kay (2001) and Haciomeroglu (2012) findings. Easier geometry problems could have helped students to express their preference for solution methods in a clearer way. If the problems were easier, the findings of this study could have been different.

Though there was not a significant correlation between preference for solution methods and task difficulty, 90% participants were found to be visualizer. However, there were not any patterns noted in visuality score for geometry problems. Only one problem has negative mean visuality score indicating that students used nonvisual solution methods over the visual solution methods and this was an easy problem in the test. Of the five easy problems (1, 8, 9, 10, and 11), only 8 has negative visuality scores. The other four problems have positive visuality scores suggesting that students have used visual solution methods for 4 of the 5 easy problems. Problems 1 and 11 have higher vsiuality scores than other tasks (except 2). Furthermore, there could be different factors why a majority of students preferred to use visual solution methods. For example, instructional strategies and technology-integrated lesson activities could have influenced students' preference for solution methods. Beyond this, even teachers' preference of instructional strategies might have affected students' preferences for solution methods.

This study found that there was a significant effect of gender only in geometry performance but not in the preference for solution methods, which is consistent with some studies (Gallagher and De Lisi, 1994, Fennema, Carpenter, Jacobs, Franke, and Levi, 1998) as well as contradict other studies (Galindo, 1994; Haciomeroglu & Chicken, 2012; Haciomeroglu, Chicken, & Dixon, 2013; Lowrie & Kay, 2001). In contrast to several studies including a Meta-analysis on gender difference reported by Lindberg, Hyde, Linn (2010), female students outperformed male students in geometry performance in this study. Although there was not an association between preference for solutions methods and geometry performance, it appeared that participants in the study tended to use more visual solution methods. The mean visuality score for each of the problem (except the one problem) was more for the visual solution methods over the nonvisual solution methods. One of the reasons for this result, similar to the study conducted by Calvin et al (2010) in which girls who used visual solutions methods outperform boys in mathematical reasoning abilities, participants used visual solution methods more than nonvisual solution methods.

The findings of this study were also consistent with the findings of Calvin, Fernandes, Smith, Visscher, and Deary (2010); Felson and Trudeau (1991); and Lawton (1997), who found that female students' performance was significantly higher than male students' performance. However, this is not consistent with some of the previous research studies (Battista, 1990; Fennema, 1974; Fennema & Sherman, 1978; Guay & McDaniel, 1977; Maccoby & Jacklin, 1974; Matteucci & Mignani, 2011), who reported that male students outperformed female students in mathematics performance. Lindberg, Hyde, Linn (2010) reported no gender differences in mathematics performance. The (in)consistency in the findings in gender differences in geometry performance might have caused by the nature of mathematics problems. Solving geometry problems may be significantly different than completing arithmetic or algebra problems, which might contribute to gender difference (Meyer, 1989). For example, there was no gender difference in arithmetic or algebra problems; however, gender difference was found in geometry (Hyde, Fennema, & Lamon, 1990). Moreover, the inconsistency in the findings of this study can be explained by the nature of the assessment used to measure students' performance. Dickerson (2012) reported that females outperformed in curriculum based assessment, which might be one of the reasons that female outperformed males in this study since EoC was curriculum-based assessment. There could be other reasons, studied by researchers, such as girls are far better than boys at self-regulating behavior and are less likely to be disruptive and inattentive at school.

Mathematics is considered to be a male-dominant subject (Fennema & Sherman, 1977) because females are simply less interested than males in mathematics (Noddings, 1998). However, people's perceptions for mathematics might have been changed in the last couple of decades. Parents might have particularly encouraged their daughters to enroll in more mathematics courses. This could one of the reasons that female outperformed male in this study. It is apparent that teachers have greater roles in students' performances. Despite of the perception of mathematics as a male-dominant subject, teachers likely encourage female students in mathematics lesson. For example, teachers rated females' math achievement significantly higher than that of males (Robinson & Lubienski, 2011). This could be another reason that female outperformed male in this study. The findings of this study could be important and interesting from a gender-issue perspective; however, it is too early to generalize the findings because the sample size of this study was small. Therefore, more research studies need to be conducted with greater sample size in various content areas of mathematics to further examine the findings of this study.

The researcher also believes that various factors are associated with the relationship between mathematics performances. There might be some theories that explain gender differences in mathematics performance (Carr, Steiner, Kyser, and Biddlecomb, 2010), but no single theory can be used to explain gender difference in mathematics because there can be various factors such as influences of parents and their educational backgrounds, students' motivational factors, instructional strategy, utilization of visual representation in instructional strategies, demography, location of schools etc., could have influenced gender differences in preferences solution methods and mathematics performance. Additionally, there are various factors, such as students' Socioeconomic Status (SES), grade, age, number of mathematics courses students taken, confidence in learning mathematics, mathematics content etc., which could have contributed to (in)consistency in the findings regarding gender differences in mathematics performance between this study and various other studies. For example, confidence in learning mathematics is an effective factor related to mathematics achievement (Tartre & Fennema, 1995). Therefore, more research studies need to be conducted taking various factors into account holistically and partially.

Implications for Teaching

The finding of this study indicated that the majority of students preferred to use visual solution methods. Moreover, results of statistical analysis indicated that as the geometry problems appeared to be difficult, students tended to use more visual solution methods. However, it is essential for students to develop both solution methods because some problems are easier to solve using visual solution methods over nonvisual solution methods and vice-versa. Thus, the developments of only one-sided preferences for solution methods result in narrow mathematical development for students because they do not have an opportunity to see mathematics problems from the other perspective. In fact, students who use only (non)visual solution methods may have a limited understanding while they learn mathematics and solve problems. Similar to the recommendation made by Haciomeroglu, Chicken, and Dixon (2013), Haciomeroglu, Aspinwall, and Presmeg (2010), and Clements (2014), the instructional strategies need to focus on students' development of balance in their knowledge and skills between visual and nonvisual solution methods.

This study also unveiled that the majority of students were found to be visualizers. Because students had a strong preference for visual solution methods, either more emphasis on nonvisual solution methods needed to be in lesson activities. To be proficient in mathematics, students are encouraged to develop preference for both visual and nonvisual solution methods. Some mathematics problems can be solved in an easier way when they are solved with a (non)visual solution method. For example, when students used visual solution method to solve certain problems of the geometry test, the majority of them failed to solve the problems. However, when students used nonvisual solution methods, the majority of them were able to provide the correct answer. Thus, based on the nature of mathematics problems, one specific solution method to solve mathematics problems can be more useful over the other solution methods. Thus, it is equally important to develop both visual and nonvisual preference for solution methods in order to be a successful learner and performer of mathematics.

Nonvisual teachers might over-emphasize rote memorization of mathematics rules and formulae for success in mathematics whereas visual teachers might be over reliant on figures and diagrams to assist their students to learn mathematics. In doing so, teachers inhibit students' opportunity learning mathematics employing visual as well as nonvisual solution methods. Teachers might be unaware of the fact that they are over reliant on only one instructional strategy, which might lead their students to develop preference for using only visual or nonvisual solution methods. Thus, it is suggested that instructional strategies should be focused on incorporating both preferences visual and nonvisual solution methods in mathematics lesson activities.

Limitation and Recommendations for Future Research

As stated earlier that majority of students were found to be visualizers. There could be different factors why a majority of students preferred to use visual solution methods. For example, instructional strategies and technology-integrated lesson activities could have influenced students' preference for solution methods. Beyond this, even teachers' preference of instructional strategies might have affected students' preferences for solution methods. Thus, researchers could further investigate various factors in conjunction with students' preference for solution methods. Including the quantitative research, the researchers recommend conducting more qualitative studies to delve deeper into preference for solution methods, gender differences, and mathematics performance. The qualitative studies would be helpful to find why students prefer to use one solution method over the other and how they develop one-sided preference for solving mathematics problems.

Some researchers identified factors such as cognitive abilities, socioeconomic status etc., underlying gender difference in mathematics while others found that gender differences in mathematical performance was due to differences in preferred mode of processing mathematical information. Thus, more research studies need to be conducted in in order to explore the gender differences in mathematical performance. Moreover, the geometry test did not cover the entire content of a high school geometry curriculum. Thus, the results and findings reported in this study could have been different if the geometry test had been designed based on different geometry topics other than those used in this study.

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