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Algebra Tiles Manipulative and Gender Differences in Learning and Achievement in Mathematics: A Case of Sunyani West Municipality

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Abstract
The issue of gender differences in the learning of mathematics has attracted the attention of many educational researchers for quite a long time for which many researchers have been researching into to understand and to find how best to resolve or minimize it. This issue steered the purpose of the study which was to investigate into the role of algebra tiles manipulatives and gender differences in learning and achievement in mathematics especially in algebra. Three schools were randomly selected from the Sunyani West Municipality for the study. A total of 70 students from three intact classes selected from these schools participated in the study. The students were pre tested to find their entry characteristics. They were then extensively taught for three weeks using the algebra tiles manipulatives. Mathematics achievement test was used to assess the students on the effectiveness on the instructional strategy. The study unveiled a significant relationship between student attitude to using the manipulatives and their mathematics achievement. The study also showed no significant differences between boys and girls performance on the post test administered at the end of the treatment. Implications of the findings were discussed and recommendations made for classroom practices.
Keywords: Manipulatives, algebra tiles, attitudes and performance

1. Introduction

The development of every nation depends on its citizens comprising - both males and females. Equipping both sexes for effective contribution to the nation's development is therefore very much important in our educational setting. It is believed that people can manage their personal life as well as professional duties when they are well educated, and mathematics as a subject has proved itself an indispensable tool for the development of a person and the nation as a whole. This has made mathematics receive a lot of recognition in many parts of the world. As a result many researchers and stakeholders have developed a growing interest in finding out students performances in mathematics due to its importance within and across the educational curricula. Although a lot of researches indicate an unclear gender differences in learning mathematics during the elementary school years, boys perform better than their girls' counterparts during intermediate school years and continue to high school (Alkateeb, 2001). Hedges and Nowell; and Randhawa (as cited in Alkateeb, 2001) found in a study that males in general outperformed females in mathematics during high school years.

Beller and Gafni (1996) conducted a study to investigate differential performance of boys and girls during the second International Assessment of Educational Progress in mathematics performance for ages 9 and 13. Analysis of results indicated that mathematics performance was in favour of the boys. In the study of the pattern of mathematical achievement of secondary schools in Ghana conducted by Eshun (1999), he found that although there was low achievement by majority of the students, boys performed relatively better than girls.

Bolaji (2007) conducted a study in which males and females were to indicate their expectation in undergraduate mathematics course and further studies where possible. Results indicated no sex-difference in the level of confidence expressed by students in their ability to complete their bachelor's programme. However, females expressed less confidence than males in their ability to obtain a masters or doctorate degree. He concluded that although that intention was related to confidence level, a disparity between females and males was found even with groups of the same level of confidence. In addition was an instance where a female tertiary student had to change her major course from Mathematics to English (Awanta, 2000).

The first International Study of Achievement in Mathematics conducted in 1964 by International Association for the Evaluation of Educational Achievement (IEA) found differences in favour of males in most of the 12 countries studied. Assessment of Grades 6 and 12 students taking same numbers of mathematics courses by the California State Assessment of Mathematics in 1978 revealed that girls did consistently better than boys in computation which involved whole numbers, fraction and decimals. The girls also outperformed boys in single one-step word problems, recall, and identification of geometric shapes and problems involving money. However, boys performed better than girls on word problems requiring reasoning ability or on multiple-step problems. Boys also scored higher than girls on problems involving spatial relationship, in the skills of measurement, geometry, application and statistics and probability (Hunsen, as cited in Nkani, 1993).

Although the above studies are in favour of boys, a study by Alkhateeb (2001) explored gender

differences in mathematics achievement of students in the last grade of high school and changes in these differences over a 10-year period. Findings indicated no significant overall differences. However in the last 6 years, females scored higher, although effect sizes were small.

Santos, Ursini, Ramirez and Sanchez (2006) noted that recent year's research shows no significant differences in achievement between boys and girls as they start getting acquainted with mathematics, differences favouring male students begin to emerge with time.

Some observed factors influencing the study of mathematics have been the perceived usefulness of mathematics for future education and career plans (Eshun, 2000). According to Eshun, females believe that they need less mathematics to manage their life, whereas males are much more apt to report that mathematics is essential for whatever career they plan. This perception when continued will affect females learning of mathematics which will make them see mathematics–related careers as possibilities. The sex-differences in perceived usefulness are also related to the stereotyping of mathematics as male domain.

This is also evident in our societies where males seem to dominate in careers such as engineering, surveying, laboratory technicians and others which use mathematics as a tool. Also evident is our mathematics and physics lessons in school, where we seem to learn more about Einstein, Newton and Pythagoras, but no theories put forth by female scientists. It is therefore not surprising that females tend to avoid mathematics because they think it is meant for males. (Eshun, 2000). He adds that mathematics is seen as a difficult and most feared subject among the school curricula by students especially females.

1.1 Statement of the Problem

The issue of gender differences in mathematics performance by various researchers (Beller & Gafni, 1996; Eshun, 2000; Hedges & Nowell; Randhawa, as cited in Alkateeb, 2001) has raised a major concern in the teaching and learning of mathematics. To this effect, many researchers have investigated into several areas such as teachers characteristics and female students achievement (Awuah, Eshun & Sokpe, 2011); gender differences in attitude and mathematics performance (Eshun, 2000) and various recommendation in suggesting innovative ways of teaching mathematics are made through such works to improve upon classroom practice as well as improving females performance in mathematics. However, many studies have shown that instruction that makes use of instructional materials or manipulatives have positive influence on student's performance (Sowell, 1989; Kurumeh, Chiawa & Ibrahim, 2010). Heddens (1997) defines manipulative as "any material or object from the real world that learners move around to show mathematical concepts" (p. 47). He adds that the use of manipulatives help in understanding the basic concepts in learning mathematics. The uses of such materials provide the teacher or instructor with multiple ways of presenting basic mathematical concepts to learners. Larbi (2011) opines that mathematical lessons should involve multiple instructional techniques. When several different instructional techniques are used in a lesson, it enables students with different learning style to develop mathematical understanding through at least one of the techniques used.

Since research indicate gender differences in mathematics performance and the use of manipulatives have shown to improve students' performance, this research seeks to explore if the use of manipulatives could help bridge the gap in gender differences in mathematics performance.

1.2 Research Objectives

The objective of this study was to explore the extent of using algebra tiles manipulatives to improve students' performance in mathematics as well as bridging the gap in gender differenhce in learning mathematics.

1.3 Research Questions

The study was guided by the following research questions.

1. How comparable are boys and girls in attitudes to using manipulative 'algebra tiles' in learning mathematics?
2. Is there any relationship between students' attitude to using manipulatives and performance in mathematics?

1.4 Research Hypothesis

The following hypothesis was formulated and tested at 5% significant level.

1. There is no significant difference in the mean scores of the boys and girls taught using algebra tiles manipulatives.

2. Review of Related Literature

2.1 Students Attitude towards Mathematics

Attitude basically is a predisposition one has about something. It is the ability or tendency to respond or react to situations. According to Allport (as cited in Mensah, Okyere & Kuranchie, 2013), attitude is a mental or neural

state of readiness, organized through experience, exerting a directive or dynamic influence upon the individual's response to all objects and situations which are related. Thus attitude is formed through individual's experiences. Attitude formation can also be explained using the three major learning theories which are classical conditioning, operant conditioning and observational learning. Classical conditioning is a formation of behaviour in which repeated conditioned and unconditioned stimulus lead to development of conditioned response (Ntim, 2010). Hence classical condition can be used to explain students' developed attitude towards certain subjects. For instance a situation where a particular method of teaching which does not conform to student's learning habits is continually used in a lesson, it results in a student's reduced interest or love for the lesson and hence affects the person's attitude towards the subject.

2.2 Manipulatives Use and Mathematics Achievement

Manipulatives according to Heddens (1997) is any material or object from the real world that learners can hold, touch and move around in the learning and formation of mathematical concepts. They are materials that appeal to several senses of the learner. He adds that the use of manipulatives in teaching and learning of mathematics holds the promise that it arouses and sustains learners' interest in an activity, ensures active participation of learners and enhances students' learning. Although the importance of manipulatives is generally accepted by primary school teachers, recent studies of students learning of mathematical concepts and processes have created new interest in the use of manipulatives across all grades. In addition, the National Council of Teachers of Mathematics has encouraged the use of manipulatives at all grade levels since 1940 (Bellonio, 2001). Although not all authors approve the use of manipulatives, many research finding support the use of such materials in the teaching and learning of mathematical concepts (Sowell, 1989).

Suydam and Higgins (as cited in Thornton, 1995) in a review of activity – based learning in mathematics instruction from kindergarten through grade 8 observed that mathematics achievement increased when manipulatives were used. Out of 40 studies that were reported, 24 showed significant positive effect of manipulatives on students' achievement, 12 showed no difference in achievement between the manipulatives and non-manipulatives, and four studies showed positive achievement using non-manipulatives.

Larbi (2011) conducted a study to investigate the effect of algebra tiles manipulative on students' performance in algebra. Two intact classes from two schools were selected for the study and were assigned experimental and control group. The experimental group was taught using the algebra tiles manipulative whiles the control group received instruction using the traditional method, a treatment which lasted for three weeks. Finding from the study showed that there was significant difference between the two groups in favour of the group that received instruction using the algebra tile manipulatives. It was concluded that the use of manipulatives promote student understanding in the learning of mathematics. In a similar study, al-Absi and Nofal (2010) found statistically significant differences between the two groups in favour of the experimental group, those who were taught using the manipulatives.

2.3 Gender Differences in using Manipulatives

Although males tend to like physical activities than females, research indicates that females are geared towards the use of manipulatives in mathematics learning than males do. Car and Jessup (as cited in Carr, Jessup & Fuller, 1999) found that first grade girls frequently used manipulatives to count on or count all in solving computational problems whereas boys rely on memory in retrieving basic mathematics facts. Also reported by Carr, Jessup and Fuller (1999) was the finding of Fennema, Carpinter, Jacobs, Franke and Levi that there exists gender differences in strategies used in solving mathematics problems. In early elementary schools, girls tend to use counting procedures to model mathematical computation than boys do.

Carr, Jessup and Fuller (1999) conducted a study to examine how parents and teachers influenced the development of gender differences in mathematics strategy used in first grade. Children were interviewed about their strategy use, the metacognitive knowledge about specific strategies, and their perceptions of parents and teachers attitudes toward various strategies. Parents and teachers completed questionnaire about the types of strategy and matacognitive instruction they provided. Results indicated that boys correctly used retrieval strategies in doing mathematics whilst girls tended to use overt strategies including the use of manipulatives.

Carr and Davis (2001) designed a study to examine whether first grade girls' use of manipulatives reflected gender differences in their ability to use the strategies or gender differences in preferences for strategy use. 84 first grade students, 42 boys and 42 girls from two sub-urban elementary schools participated in the study. The children solved basic arithmetic problems under two conditions: a free choice condition in which they were allowed to solve the problems in any way they preferred and a game condition in which the children's strategy used was constrained so that all children used the same strategies on the same arithmetic problems. It was found during the free choice session that girls tended to use strategies utilising manipulatives and boys used retrieval. During the game conditions, when the researches controlled the types of strategies children used on different problems, they found that girls were as able as boys to calculate solutions to the mathematics problems. Girls

however, were not as capable as boys in retrieval of answers to arithmetic problem from memory. This was an indication that girls' thinking process might have been enhanced when they had opportunity to work with the manipulatives.

According to Heddens (1997), manipulatives are materials from the real world that children interact with to enhance concepts formation and understanding of mathematics. One can infer then that, since females are known to make good use of manipulatives in their learning process, and manipulatives are also known to enhance concept formation and improve understanding in mathematics, it will enhance female performance and help bridge the gap between girls' and boys' performance in mathematics as the literature shows.

For instance, research has shown that when girls and boys are instructed through extensive use of manipulatives, girls benefit most, which enable them to perform at almost equal level as their male counterparts.

Yang and Chen (2010), conducted a study to examine the effect of a digital pentaminoes game on two essential human factors especially gender differences and spatial ability on students' performance. The results showed that students' spatial abilities were significantly improved after they took the pentaminoes game. The results also demonstrated that the digital game reasonably reduced the difference between boys' and girls' performance in mathematics.

Kurumeh, Chiawa and Ibrahim (2010) designed a study to investigate the effect of Dienes block approach on students' interest in number bases. The study adopted non-equivalent control group quasi experimental design. Results from the study indicated that the experimental group had higher mean score, which resulted in better performance than the control group who were taught without such approach. The results also showed no significant difference in the mean scores of males and females in the experimental group. The conclusion drawn in the study was that manipulative approach to instruction is effective in improving and enhancing students' performance as well as providing learning experience that is beneficial to all irrespective of gender. The finding of Kurumeh, Chiawa and Ibrahim (2010) is not different from that of al-Absi and Nofal (2010) who also found no differences is student marks due to gender when they were taught using manipulatives.

As a result of the link that has been made between gender and the use of manipulatives, and in view of the literature that suggests that there are gender differences in mathematics education in Ghana, it was therefore decided to investigate gender differences in the effect of the use of manipulatives on achievement.

3. Methodology

The population for the study consisted of all Junior High School in the Sunyani West Municipality in the Brong Ahafo Region of Ghana. The sample however consisted of 70 students being an intact class of three schools selected randomly from the schools in this municipality. The study was a quasi-experiment which employed the pretest, posttest design. These intact classes selected received instruction for three weeks using the algebra tiles manipulatives

The instruments used for the study were questionnaire and two mathematics achievement test, one for pretest and the other for the post test. The validity of these instruments was established by proof read by an expert in mathematics education. Suggestions received enable the researcher to modify the items in the instruments. The reliability coefficients of these instruments ranged from 0.7 to .079 which were considered good instrument for use (Wells & Wollack, 2003)

Prior to the study, the students were pretested to find their initial characteristics. The pre-test administered to the students showed significant difference in the boys (M = 13.62, SD = 4.727) and girls (M = 10.9, SD = 4.011) t(68)=2.547, p = 0.013. The students were taught using the algebra tile manipulatives by carefully following the lesson plan developed for the treatment. The instructional period lasted for three weeks after which the students were tested using the posttest to find their performance. The collected scripts were scored and the scores analysed using the SPSS version 16. The statistics tools used for the study were independent samples t-test and Pearson product moment correlation.

4. Results and Discussion

The focus of the study was to investigate into the role of the use of manipulative materials specifically algebra tiles in the learning of algebra. This section presents the analysis of the data in order of the research questions.

Research Question 1

How comparative are boys and girls in attitudes to using the manipulative 'algebra tiles' in learning mathematics?

Table 1: Extract of t-test comparison of boys and girls in attitudes to using manipulatives

Gender	N	$\overline{X}$	SD	df	t	p
Male	39	38.51	3.77			
				68	-1.251	0.215
Female	31	39.59	3.25			

Although the mean response of females with regard to their attitudes in using manipulatives was higher than that of the males, the table shows no significant difference in the mean response of both boys (M=38.51, SD = 3.77) and girls (M = 39.59, SD = 3.253); t(68) = -1.251, p = 0.215. Since $p > 0.05$, there is no evidence to suggest that differences existed in the boys and girls attitude towards the use of the manipulatives. However, both groups had a higher attitudinal mean score (greater than 30). This maintains claim that the uses of manipulatives arouse and sustain students' interest and ensures their active participation in the learning process (Heddens, 1997; Munger, 2007). Students assimilate knowledge when they are given the opportunity to explore and talk about their discoveries. Although the difference in boys and girls attitude to the use of the manipulatives materials was not significant, the higher mean score of the girls seems to suggest girls having more interest in using manipulatives than the boys. This finding is not different from Carr and Jessup (as cited in Carr, Jessup & Fuller, 1999) who found girls to frequently resorting to the use of manipulatives in solving computational problems in mathematics than the males. Since mathematics is abstract and comes from the real world, the use of real materials in teaching the subject can help students' formation of concepts and develop positive attitude towards its teaching and learning.

Research Question 2
Is there any relationship between students' attitude to the use of manipulatives and mathematics performance?

Table 2: Correlation between Students Attitudinal Score and Performance

Pearson Correlation	0.523
Significance (2 – tailed)	0.000
N	70

Table 2 shows a positive Pearson correlation coefficient of 0.523. It also shows that at 95% confidence level the result was significant. Hence the results show a positive and significant correlation between the students' attitudinal score and their performances in mathematics. Thus not only did the students show a positive attitude towards the use of the manipulatives, it also reflected in their performance on the achievement administered to them after the treatment. This supports Heddens (1997) assertion that the use of manipulatives materials holds the promise of helping students understanding of mathematics. This reaffirms Bruner's (1966) definition of learning as an active process in which the learner constructs knowledge base on his current or previous experiences. Indeed the use of manipulatives enhances learning. Students become active participants by exploring; conjecturing and discovering new ideas for themselves. It changes the teachers' position from reserve of knowledge to facilitator of knowledge. A situation which made Larbi (2011) to opine that not that what the teacher says is unimportant but what the student thinks. The constructivist believes that knowledge is constructed by the learner. It is therefore necessary that the teacher create, prepare and provide learning experiences that will encourage learning and enhance understanding.

Research Hypothesis
There is no significant difference in the mean score of the boys and girls taught using algebra tiles manipulatives.

Table 3: Extract of the Mean Scores of Boys and Girls Taught with the Manipulative

Gender	N	$\overline{X}$	SD	df	t	p
Male	39	29.87	7.20			
				68	1.046	0.299
Female	31	28.06	7.16			

Table 3 shows no significant difference in the mean score of boys (M = 29.87, SD = 7.20) and girls (M = 28.06, SD = 7-16); t(68)= 1.046, p =0.299, who were taught using the algebra tiles manipulative. Since $p > 0.05$, we fail to reject the null hypothesis of no difference of boys and girls performance after they have been taught with the algebra tile manipulatives. Thus boys and girls who received instruction through this strategy performed at pall. This finding supports (Kurumeh, Chiawa & Ibrahim, 2010; al-Absi, & Nofal, 2010) both studies which found no difference in boys and girls performance after they have been taught with manipulatives. As there are different teaching styles, so are different learning styles of the learners. The use of the manipulatives appeals to several senses of the learner and as well ensures that students with different learning style also benefit from this instructional strategy. The learners understanding is given highest priority in the teaching and learning process, and it is generally felt that such understanding can only follow the individual's personalised perception or learning style. The use of manipulatives enables students to model abstract concepts and gives them the opportunity to communicate ideas among themselves and to the teacher, and also enhance memory. According to Bruner (as cited in Resnick, & Ford, 1984), knowledge acquired without sufficient structure to tie it together is

knowledge that is likely to be forgotten.

Conclusion

The following conclusions are drawn from the findings of the study:

1. The use of the tiles enhanced students meaningful and concept learning.
2. Students had positive attitude towards the use of manipulatives as exploring with such materials gave them the opportunity to understand and internalized the new concept treated.
3. The use of the manipulatives helped bridge the gap between boys and female performance in mathematics.

Recommendation

1. Algebra tile manipulatives should be used as much as possible to introduce students to algebraic concepts and teaching mathematics as a whole
2. Workshops on the use and updates of manipulative materials should be organized for teachers on regular basis since knowledge gain is a continual process and knowledge grows in itself.
3. Mathematics educator should often use manipulatives to teach both sexes

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