Effects of Mnemonic and Prior Knowledge Instructional Strategies on Students' Attitude to Mathematics

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ABSTRACT

The study examined the effects of Mnemonics and Prior Knowledge Instructional Strategies on Students' Attitude to Mathematics. Moderating effects of Numerical Ability and Gender were also investigated. The study adopted the pretest-posttest control group, quasi experimental design with 3x2x3 factorial matrix. Two hundred and eighty-eight students from six public schools selected from three local government areas in Ibadan, Oyo State, Nigeria, participated in the study. Two instruments were developed and used: Students' Mathematics Attitudinal Scale (r=0.8) and Numerical Ability Test (r=0.77). Also used were three operational guides on Mnemonic Instructional Strategy, Prior Knowledge Instructional Strategy and Traditional Teaching Method. Four Null hypotheses were tested at 0.5 significant levels. Data collected was analyzed using Analysis of Covariance, Multiple Classification Analysis (MCA) and Scheffe Post hoc test. Treatment has significant effect on students' attitude to mathematics ($F_{(3,284)}$, 3.933), $p<0.05$). Students in the control group had higher attitude mean score of 71.39 than those in MIS 69.01 and PKIS 68.46. Numerical ability has no significant effect on students' attitude to mathematics ($F_{(3,284)} = 0.15$, $p<0.05$), but gender has significant effect on students' attitude to mathematics. Though the control group had the highest mean score, it has been revealed that MIS and PKIS improved students' attitude to mathematics significantly. Therefore, teachers should create mnemonics that link old and new information in the students' memory, assess their knowledge at the start of instruction through examples that bridge students' prior knowledge with the new to ensure improved performance and make teaching and learning of mathematics students-centered.

Keywords: Mnemonic instructional strategy, Prior knowledge instructional strategy, students' attitude to mathematics, Numerical ability, Gender

INTRODUCTION

Mathematics is one of the most dreaded subjects at all levels of education, especially secondary schools where the subject is compulsory irrespective of the class and despite its usefulness to every aspect of human development. It has been described as the bedrock of national development and a subject without which a nation cannot move forward scientifically and technologically (Alutu and Eraikhuemen, 2004). It is the wheel on which science subjects move and the prime instrument for understanding and exploring our scientific, economic and social world (Amoo and Rahman, 2004). Mathematics is a beautiful subject that holds other subjects together, as there is a lot of Mathematics in physics, chemistry and geography (Ale, 2011). Tsue and Anyor (2006) see Mathematics as the language of science and technology. Mathematics concepts and methods provide scientists

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with insight into natural phenomenal, while its symbols are used in expressing the physical laws of nature. Therefore, to move any nation forward scientifically and technologically, Mathematics is very important. On the basis of this, it has been observed that no nation can make any meaningful progress in this information technology age, particularly in economic development without technology whose foundation are science and Mathematics (Bajah, 2000). In the same vein, Adewumi (2005) concludes that without Mathematics, there is no science, without science there could be no modern technology.

However, despite the importance and contributions of Mathematics to every facet of human development, the subject is still faced with the problem of poor performance by the students at secondary school level at least in Nigeria. Several factors have been identified by researchers that may be responsible for the poor performance of students in Mathematics over the years. Prominent among these factors are: poor attitude of students to Mathematics (Ifamuyiwa & Akinsola, 2008; Akinsola & Olowojaiye,2008), the use of traditional or conventional teaching method (Alio 2000 and Ayanniyi, 2005), non-utilisation of available resources (Akinsola, 2000a), lack of interest on the part of teaching staff (Amoo, 2001a), lack of Mathematics laboratory (Obodo, 2008), population explosion of students enrolments without commensurate Mathematics teachers to handle them (Amoo, 2002) and lack of professional training (Iheanacho, 2007).

Generally, students' attitudes determine to a larger extent their success in any subject (Akinsola and Olowojaiye, 2008). Therefore, to address the persistent poor performance of students in Mathematics, efforts must be made to improve their attitudes positively towards teaching and learning of the subject. Attitude of students is very crucial and central to the academic achievement of students in Mathematics. Therefore, it is imperative to ensure that there is a positive change in students' attitudes towards learning of Mathematics. Attitude to learning could either be positive or negative. Positive attitude reinforces affection which enhances student's performance in Mathematics or any other subject. On the other hand, negative attitude causes hatred, disaffection and depression towards Mathematics with resultant effect being poor performance in the subject. Attitude to a certain subject or situation could be formed, developed, adopted, modified or even changed due to circumstances. According to Encyclopedia of Education, attitude is defined as the pre-disposition to respond in a certain way to a person, an object, an event, a situation or an idea. Attitude is also seen as the affective disposition of a person or group of persons to display an action towards a subject based on the belief that such a person or group of persons has about the subject (Oguntade, 2000). It denotes the sum total of a man's inclinations, feelings, prejudice or bias, preconceived notions, ideas, fears, threats and conviction about any topic or subject (Akinsola and Ifamuyiwa, 2008). In the same vein, attitude towards Mathematics is just a positive or negative disposition towards Mathematics (Zan and Martino, 2007). Also, Greenwald, McGhee and Schwarts (2002) see Mathematics attitude as how an individual feels about Mathematics. Thus, the perceived importance of Mathematics is one of the essential attitudes towards Mathematics

Various researches have shown that students who have positive attitudes to a subject will perform better than those with negative attitudes. It has been revealed that students need to have positive attitude towards problem-solving to be successful and overcome the risks (O'Connel, 2000). In another sense, it has been observed that attitude of students can be influenced by the attitudes of the teacher and his method of instruction. The teacher's method

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of Mathematics teaching and his or her personality greatly accounts for the students' positive or negative attitude towards Mathematics (Yara, 2009). Thus, the attitude of a learner towards science and Mathematics would determine the extent of the learner's attractiveness or repulsiveness to science and Mathematics (Ogunkola, 2002). Therefore, if a person is not favourably disposed to Mathematics or any other subjects, his or her attitude towards the subject may be negative. Thus, positive attitude will lead to persistence and better achievement (Odogwu, 2002). To ensure high achievement in Mathematics positive components of Mathematics such as likeness, usefulness and relevance of Mathematics to other subjects and everyday living should be reinforced during instruction. On the basis of the above, the study therefore examined the effects of Mnemonic and Prior Knowledge Instructional Strategies on the attitude of students towards teaching and learning of Mathematics.

One other key factor that may be responsible for the poor performance of students in Mathematics is the use of Conventional Teaching Method (otherwise known as Lecture Method). This method, though, prevalent in Nigerian Secondary Schools and most commonly used by teachers, has been shown to be ineffective and has not been yielding the desired results (Akinsola, 2000b). It is teacher-centred where the teacher dominates the class, leaving learners uninvolved and passive. This method of teaching is not interactive and may render the set objectives unachievable (Aremu, 2010). Also, Ayoade (2006) asserts that the Conventional Teaching Method fails to respect individual differences and learning characteristic. According to Berns and Erickson (2001) the traditional approach to education where students receive direct instruction and then practice specific skills is not good enough for critical thinking. Therefore, there is need to search for alternative method of instruction in Mathematics that will be effective in helping learners to understand and retain what is learnt, improve their attitude and enhance their performance. Based on this, the study looked into another set of instructional strategies called Mnemonic and Prior Knowledge, which are cheaper with respect to time and cost of implementation, and may improve students' performance through quick recall of basic and specific facts that are necessary to succeed in virtually all forms of examinations.

Mnemonics instruction is a systematic procedure for enhancing memory. According to Babara (2005), Mnemonics instruction is a set of strategies designed to help students improve their memory of new information. Its particular use is in developing better ways to take in (encode) information so that it will be much easier to remember (Mastropieri and Scruggs, 1992). The particular task in developing mnemonics strategies is to find a way to relate new information to information students already have locked in long-term memory. Mnemonic instruction links new information to prior knowledge through the use of visual and/or acrostic cues. Visual cues are pictures or graphics teachers create that link the old and new information in the student's memory. For example, a mnemonic to remember the definition of the word "carline" (meaning witch) might be a drawing of a witch driving a car. Acrostic cues on the other hand involve words arrangement in which the first letter of the words correspond to the first letter of the information students are expected to remember. One bigger advantage of Mnemonic instruction is that it is an inexpensive strategy that helps average children gain access to general education curriculum. No specific level of teaching experience is required to learn or use this strategy. Mnemonic instruction involves no additional costs for purchase of material or technology. Therefore, using Mnemonic instructional strategy in teaching Mathematics would enhance students' memory of basic

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Mathematics facts and ensure quick recovery of important information that would improve academic performance of students.

Prior Knowledge is all knowledge learners have when entering a learning environment that is potentially relevant for acquiring new knowledge (Biemans**,** Deel and Simons, 2001). Also, Dochy and Alexander (1995) describe Prior Knowledge as the whole of a person's knowledge including explicit and tacit knowledge, meta-cognitive and conceptual knowledge. The students' Prior Knowledge provides an indication of the alternative conceptions as well as the scientific conceptions possessed by the students (Hewson and Hewson, 2008). In the construction of knowledge, learners use Prior Knowledge to incorporate meaning into newly acquired material. In this way, Prior Knowledge influences how learners interpret new information and decide what aspects of this information are relevant and irrelevant. To achieve expected result when using Prior Knowledge instructional strategy, Hewson and Hewson (2008) opine that teachers should assess students' knowledge at the start of instruction, probing for underlying assumptions and beliefs. Challenge students' common misconceptions by providing examples that prove otherwise. Tailor instructions and explanations to accommodate individuals' Prior Knowledge and experience when possible. This may be done through providing analogical examples that bridge students' Prior Knowledge with the new concepts they are to learn.

However, Prior-Knowledge can make it difficult to understand or learn new information (National Research Council, 1999, Dochy et al, 1999). Difficulty is especially likely if pre-existing information is inaccurate or incomplete, such as when students generalize in-appropriately from everyday experiences or from what they learn in the popular media (Chinn and Brewer, 1993). Remarkably, prior beliefs may be highly resistant to change, even in the context of formal course work (Fisher, Wandersee, and Moody, 2000). To counter the effect of inaccurate pre-existing information, it is necessary to activate Prior Knowledge which is critical and essential to the content to be discussed. Active review, rather than passive, should be conducted at the commencement of the lesson, during the lesson, and when concluding the lesson. By this, students are continuously recycling important information, which relates to both current and past topics (Susan, 2009). Thus, evidence from research on Prior Knowledge Instructional Strategy showed that students are not blank slates on which our words are inscribed. The students bring more to the interpretation of the situation than we realize. What they learn is conditioned by what they already know. What they know can be as damaging as what they don't know (Svinicki, 2011).

Gender is one of the most interesting and actively debated variables in educational research, but with conflicting results. Some studies have reported a significant relationship between gender and students performance in mathematics, especially in favour of boys (Scantlebury and Baker, 2007). It has been reported that male students have higher level of achievement in science, technology and mathematics than their female counter part (Ige, 2001; Raimi and Adeoye, 2002). The boys are superior in numerical aptitudes, science, reasoning and spatial relationship while girls are superior in verbal fluency, perceptual speed, memory and manual dexterity (Terman and Tyler in Akinyele and Ugochulunma, 2007). However, it was reported that gender did not have any significant effect on variation in achievement scores of boys and girls (Badiru, 2007; Okigbo and Oshafor, 2008). Furthermore, another variable that is critical to the achievement of students in Mathematics is numerical ability. Numerical Ability is the capability of students to perform some arithmetical or mathematical calculations off-hand or

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without the use of any mechanical device. It could be high, medium or low Numerical Ability.Some studies have shown that students' Numerical Ability could influence learning and retention and scholastic attainment (Inyang and Ekpeyong, 2000 and Adeoye and Raimi, 2005). It has also been observed that Numerical Ability to a great extent determines the imagination, language, perception, concepts formation and problem solving ability of learners (Arowolo, 2010).The finding provided further empirical support to that of Superka (2004), Stronghill (2004) and Graffit (2004) that Numerical Ability had significant effect on teachers' knowledge of environmental concepts and their attitude to the environment than gender.

STATEMENT OF THE PROBLEM

The poor performance of students in Mathematics in both internal and external examinations especially by Nigerian students has been of serious concerns to all stakeholders in the education sector. This may be attributed to several factors among which is the use of the Conventional Teaching Method of teaching that dominates our classrooms and makes teaching and learning of Mathematics uninteresting and students' attitude towards Mathematics very poor. Most importantly, students find it extremely difficult to recollect basic Mathematics facts needed to enhance their performance if teaching of Mathematic is meaningful and related to the previous topics already covered. To redress this situation, however, there is need to find instructional strategies that will address the problem associated with the Conventional Teaching Method and make teaching and learning of Mathematics students-centred. Based on this, this study therefore investigated the effects of two instructional strategies: Mnemonics and Prior-knowledge on Senior Secondary School Students' attitude to Mathematics. Also, moderating effects of gender and Numerical Ability on students' attitude to mathematics was investigated.

HYPOTHESES

$H0_1$ – There is no significant main effect of treatment on students' attitude to Mathematics.

HO_2 - There is no significant main effect of numerical ability on students' attitude to Mathematics.

HO3 – There is no significant main effect of gender on students' attitude to Mathematics.

HO_4 – There is no significant interaction effect of treatment, numerical ability and gender on students' attitude to mathematics.

METHODOLOGY

This study adopted a pretest-posttest, control group quasi-experimental design. Two experimental groups were exposed to Mnemonic and Prior-Knowledge instructional strategies respectively. The control group was exposed to Conventional Teaching Method. All the three strategies were crossed with gender at two levels (male, female) and Numerical Ability at three levels (high, medium, low). From each of the selected schools, two intact classes were used. In all, two hundred and twenty (288) SS2 students, comprising boys and girls were used in the study.

Instrumentation

The following instruments were developed and used to elicit responses for this study:

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1. Students' Mathematics Attitudinal Scale (SMAS)
2. Numerical Ability Test (NAT)

Students' Mathematics Attitudinal Scale (SMAS)

The instrument was adopted from Fenema-Sherman attitude scale. The instrument consists of two sections, A and B. Section A contains questions on student's background information such as: name of school, age, class and sex. Section B consists of 25 items covering such areas as: personal confidence about mathematics, usefulness of mathematics, perception of mathematics as male dominated subject, perception of teacher's attitudes, career aspiration and relationship of mathematics to other subjects. The instrument was designed based on a four point Linkert Scale of Strongly Agreed (SA), Agreed (A), Disagreed (D) and Strongly Disagreed (SD). The scores for SA, A, D and SD were 4, 3, 2, and 1 for positively worded statements and reversed for negatively worded statements respectively. For validation, the instrument was administered as a trial-test to 20 students, comprising males and females, of a school not among the participating schools and not within the selected local governments. The reliability coefficient of the instrument of 0.8 was obtained using Cronbach Alpha. The earlier validation by Martha (2004) showed the reliability coefficient Alpha of .97.

Numerical Ability Tests (NAT)

The instrument was adapted from the Psychometric Success Numerical Ability Test. The instrument which consists of only one section has 37 questions with various degrees of difficulties. The instrument was administered to 20 students (11 males and 9 females) as a trial-test. The reliability coefficient of 0.77 was obtained with Kuder Richardson 20 (KR 20). The scores obtained from the tests were converted to percentages and used to group the students into high, medium and low numerical ability. Based on these, students who scored 60% and above were considered high numerical ability, 40 – 59% medium numerical ability, while 0 – 39% low numerical ability. This formed the criterion for partitioning the students into ability groups.

Procedure for Treatment

The first three weeks were used for the training of Mathematics Teachers that participated in the teaching. The training was done by the Researcher. The fourth week was used for conducting pre-test in Students Mathematics Attitudinal Scale; this was done by the researcher with assistance of Mathematics Teachers. Week five to twelve were used for the treatment in the six schools selected for the experiment. The teachers for the experimental group I were given material and guidelines relating to Mnemonic Instructional Strategy and were expected to identify relevant mnemonics before the commencement of the lesson. The teachers for the experimental group II were also provided with materials relating to Prior Knowledge Instructional Strategy and were expected to review actively at the commencement, during and at the conclusion of the lesson relevant topic that could enhance the understanding of the new topic. The teachers for the control group were not provided any material. They were expected to follow the conventional method of instruction. The thirteen week was used for conducting the post-test in respect of SMAS.

DATA ANALYSIS

Data collected was analysed using the Analysis of Covariance (ANCOVA). The Multiple Classification Analysis (MCA) was used to determine the magnitude and direction of

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differences due to the groups. Where significant main effects were found, Scheffe post-hoc pair wise comparison was used to determine the source of significance. All research hypotheses were tested at the 0.05 level of significant.

H_o1: There is no significant main effect of treatment on students' attitude to Mathematics.

Table 1. ANCOVA table showing the significant main and interaction effects of Treatment, Numerical Ability and Sex on the Pre-Post Students' attitude to Mathematics

Source	Sum of Squares	DF	Mean Square	F	Sig.
Corrected Model	1514.020	18	81.112	1.249	.222
PREATT	298.230	1	298.230	4.428	.036
Main Effect:					
Treatment Group	529.749	2	264.875	3.933	.021
Numerical Ability	1.965	2	.982	.015	.986
Gender	289.554	1	289.554	4.299	.039
way Interactions:					
Treatment x Mental Ability	71.568	4	17.892	.266	.900
Treatment x Gender	139.936	2	69.968	1.039	.355
Numerical Ability x Gender	103.730	2	51.865	.770	.464
way Interactions:					
Treatment x Numerical Ability	72.878	4	18.219	.271	.897
x Gender	18116.591	269	67.348		
Error	19630.611	287			
Total					

M.D = Mean Deviation

The results from table 1 above show that there is a significant main effect of treatment on students' attitude to mathematics ($F_{(3,269)}$ = 3.933, P <.05). This implies that there is a significant difference between the attitude of students exposed to Mnemonic, Prior Knowledge and Conventional Teaching Method. Hence, the null hypothesis is rejected.

To determine the magnitude of the means scores of students' attitude in each of treatment and group, the Multiple Classification Analysis (MCA) in table 2 is presented.

From table 2, the mean scores of the different Treatment Groups were given with Control group having the highest mean score of 71.59, followed by Prior-knowledge Instructional strategy 69.01, and finally Mnemonic Instructional strategy 68.46. The implication is that the Control group influences students' attitude towards mathematics than the experimental groups. The reason for this might be due to favourable attitude of teachers to the traditional method of instruction which might have influenced the attitude displayed by the students. On

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the basis of this, the attitude of the teacher had influenced the attitude displayed by the students. The finding was in line with the results of Adesoji (2008) and Yara (2009) who reported that the attitude of the students can be influenced by the attitude of the teachers and their methods of instruction.

Table 2. Multiple Classification Analysis (MCA) showing the direction of the difference in the analysis: Students' Attitude to Mathematics

Variable + Category Grand Mean = 69.82	*N*	*Unadjusted variation*	*Eta*	*Adjusted for independent + covariates deviation*	*Beta*
Treatment Group:					
1. TRT I	87	-1.36		-1.59	
2. TRT II	92	-.81		-.39	
3. Control	109	1.77	.17	1.60	.16
Numerical Ability:					
1. Low	82	-.05		.11	
2. Medium	85	-.50		-.06	
3. High	121	.39	.05	-.03	.01
Gender:					
1. Male	96	-1.34		-1.51	
2. Female	192	.67	.11	.75	.13
Multiple R-squared					.061
Multiple R					.246

In order to trace the source(s) of the significant effect of treatment on students' attitude to mathematics, the Scheffe post-Hoc analysis was carried out as presented in table 6

Table 3. Scheffe Post-Hoc Pair-wise significant differences among the various groups of independent variables on the Attitude to Mathematics between the Treatment groups

Treatment Group	*(I) Treatment Groups*	*(J) Treatment groups*	*Sig*
Post Test Attitude in Mathematics	Treatment I	Treatment II	.904
		Control	.030
	Treatment II	Treatment I	.904
		Control	.086
	Control	Treatment I	.030
		Treatment II	.086

Table 3 above shows that there were pairwise significant differences between Treatment I and Control group and vice-versa

Ho.2: There is no significant main effect of numerical ability on students' attitude to mathematics

The result from table 1 shows that there is no significant main effect of numerical ability on students' attitude to Mathematics ($F_{(3,269)}$ = .015, P >.05). This implies that there is no significant difference between Low Numerical Ability, Medium Numerical Ability and

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High Numerical Ability on Students' Attitude in Mathematics. Hence, the hypothesis is accepted.

Table 2 shows that high numerical ability obtained the highest mean score of 70.21, followed by Low Numerical Ability 69.99 and Medium Numerical Ability 69.32. Though the difference exists, however, the difference is not significant.

Ho.3: *There is no significant main effect of gender on students' attitude to Mathematics.*

The result from table 4 shows that there is a significant main effect of gender on students' attitude to Mathematics ($F_{(2,269)} = 4.299$, $P < .05$). This means that there is a significant difference in Male and Female Students' attitudes to Mathematics. Hence, the null hypothesis is rejected. Table 2 also presents the mean score of female attitudes to Mathematics of 70.49, slightly higher than their male counterpart 68.48.

Ho.4: *There is no significant interaction effect of treatment, numerical ability and gender on students' attitude to Mathematics.*

The result from table 1 show that there is no significant interaction effect of treatment, numerical ability and gender on students' attitude to mathematics ($F_{(18,269)} = .271$, $P > .05$). Hence, the null hypothesis is accepted. The implication is that the two strategies, Mnemonics and Prior Knowledge, are better irrespective of the numerical ability levels and gender of the students.

CONCLUSION

The findings of this study have shown that Mnemonic and Prior Knowledge instructional strategies were more effective in improving the students' attitudes to Mathematics. The results have revealed that the use of mnemonic instruction would enable students to remember factual information, answer questions and demonstrate comprehension. It would also provide a visual or verbal prompt for students who may have difficulty retaining information. As regards prior-knowledge strategy, it has been established that it can be used to incorporate meaning into newly acquired material. Also, it influences how learners interpret new information and decide what aspects of that information are relevant and irrelevant. Based on the findings of the study, it has been recommended that teachers should facilitate the use of Mnemonic and Prior Knowledge instructional strategies in schools to enhance positive attitude of students towards Mathematics and hopefully improved attitude may lead to better achievement in the subject. They should also include varieties of Mnemonics into their instructional strategies to effectively cater for the diverse abilities of students within their classrooms. Teachers should conduct active review of students' relevant prior knowledge at the commencement, during and at the conclusion of the lesson. Periodic and regular training, seminars and workshops should be organized for teachers to update their knowledge on current and innovative teaching strategies at secondary school level.

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