EFFECTS OF MNEMONIC AND PRIOR KNOWLEDGE INSTRUCTIONAL STRATEGIES ON STUDENTS' ACHIEVEMENT IN MATHEMATICS

Mojeed Kolawole AKINSOLA
Department of Teacher Education
Faculty of Education, University of Ibadan, Ibadan
E-mail: mk.akinsola@mail.ui.edu.ng and akinsolamk@gmail.com
and
Ezekiel Olukola ODEYEMI
Department of Teacher Education
Faculty of Education, University of Ibadan, Ibadan
All corresponding to the 1st author.

ABSTRACT

This study investigated the effects of Mnemonics and Prior Knowledge Instructional Strategies on Students' achievement in Mathematics. Moderating effects of Numerical Ability and Gender were also examined. 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 Achievement Test (r=0.75) 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. The study revealed a significant effect of treatment on students' achievement in mathematics ($F_{(3, 284)} = 8.961$, $p<0.05$). MIS had the higher achievement score of 16.91 than PKIS 13.07 and control group 12.10. Numerical Ability and Gender have significant effect on students achievement in mathematics ($F_{(3,284)} = 28.856$, $p<0.05$). Since, MIS and PKIS enhanced students' achievement in mathematics, 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.

Key words: Mnemonic Instructional Strategy, Prior Knowledge Instructional Strategy, Students' attitude to, Numerical Ability and Gender.

INTRODUCTION

The antidote to most scientific and technological problems is Mathematics. Mathematics has reduced most scientific and technological problems to simple equations that can be solved easily with some degree of accuracy and certainty. No wonder, Tsue and Anyor (2006) see Mathematics as the language of science and technology. Mathematics concepts and methods provide scientists with insight into natural phenomenal, while its symbols are used in expressing the physical laws of nature. 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). Therefore, to move any nation forward scientifically and technologically, quality mathematics education is very important (Akinsola, 2009). 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. In other words, Mathematics is the precursor and queen of science.

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. 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 and Akinsola (2008), the use of traditional or conventional teaching method (Alio 2000 and Ayanniyi, 2005), non-utilisation of available resources (Akinsola, 2000), student avoidance of mathematics (Akinsola, 2009), 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).

Furthermore, Betiku (2002), Akinsola and Ifamuyiwa (2008) ascribes dismal performance of students in Mathematics to the cluster of variables, which include: government related variables; curriculum related variables; examination bodies related variables; teacher related variables; students related variables; home related and finally text book related variables. Aside from these variables some specific variables have been identified by Amazigo (2000) such as poor primary school background in Mathematics, lack of interest on the part of the students, lack of incentives for the teachers (Akinsola, 2010), incompetent teachers in the primary schools, large classes, perception that Mathematics is difficult, and psychological fear of the subject.

Apart from the results of various research efforts to unearth the reasons for incessant and ever increasing dismal performance of students in both internal and external examinations, many stakeholders in education industry have also spoken on the issue. According to the West African Examinations Council's Report (WAEC, 2010) unimpressive performance of students was attributed to poor language skills and expression, insufficient preparation, misinterpretation of questions, inadequate technical competence and poor hand writing. The analysis of WAEC results of Senior Secondary School Certificate Examination in Mathematics from 2002 to 2011 are given in table 1 below

Table 1: Statistics of Entries and Results of West African Examinations Council in Mathematics 'O' Level at the May/June Senior Secondary School Certificate Examinations for Nigeria (2002 – 2011)

Year	No. Of Candidates	A1-C6 High Quality Passes	% High Quality Passes	D7-E8 Poor Quality Passes	% Poor Quality Passes	F9 Failure	% Failure
2002	908,235	309409	34.06	308369	33.95	290457	31.98
2003	926,212	341928	36.92	331348	35.77	252736	27.31
2004	832,689	287484	34.52	245071	29.43	300134	36.04
2005	1,054,853	402982	38.20	276000	26.16	375871	35.63
2006	1,181,515	482123	40.81	366801	31.04	332591	28.15
2007	1,249,028	583921	46.75	333740	26.72	331367	26.53
2008	1,292,890	726,398	56.18	302,266	23.38	264226	20.44
2009	1,373,009	634,382	46.20	344,635	25.10	393992	28.70
2010	1,306,535	548,065	42.00	363,920	27.90	355,382	27.20
2011	1,508,965	608,866	40.40	474,664	31.50	421,412	27.90

Source: West African Examinations Council, 2012

Table I gives analysis of students performance at the May/June Senior Secondary School Certificate Examinations Ordinary Level between 2002 and 2011. A clear look at the table shows high quality passes (A1- C6) between 2002 and 2011 range from 34.06% and 56.18%, while pass rates (D7 – E8) range between 23.38% and 35.77%. The failure rate (F9) ranges between 20.44% and 36.04%. Though there were noticeable improvements during these periods, however, with much effort on the part of the teachers, the parents, the government and the students themselves we could achieve greater percentage at the grades A1-C6.

One 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, 2000). It is teacher-centred where the teacher dominates the class, leaving learners uninvolved and passive (Akinsola,2011) 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 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) opined 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, tailored 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 counterpart (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 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).

STATEMENT OF THE PROBLEM

The poor performance of students in Mathematics in both internal and external examinations 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' achievement in Mathematics very low. 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 student-centred. Based on this, this study therefore investigated the effects of two instructional strategies: Mnemonics and Prior-knowledge on Senior Secondary School Students' achievement in Mathematics. Also, moderating effects of gender and Numerical Ability on Mathematics learning outcomes were investigated.

Hypotheses:

The following null hypotheses were tested at 0.05 significant levels

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

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

HO3 – There is no significant main effect of gender on students' achievement in Mathematics.

HO_4 – There is no significant interaction effect of treatment, numerical ability and gender on students' achievement in 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:

1. Students' Mathematics Achievement Test (SMAT)
2. Numerical Ability Test (NAT)

Students Mathematics Achievement Test (SMAT)

The test was designed by the researcher to measure the achievement of SSII students in Mathematics. The instrument was made up of two sections: Section A consisted of demographic data such as name of school, subject, gender, sex, and age. Section B consisted of 30 multiple items test taken from final draft of 40 items drawn from the mathematics concepts that were taught during the experiment. The instrument was designed to measure knowledge, understanding and thinking. Each multiple choice item has four options A to D. One mark was awarded for each question answered correctly and zero for every wrong answer. The maximum mark was 30. To validate the instrument it was given to three experienced mathematics teachers who have been teaching the subject at Senior Secondary level for more than 5 years for face and content validity. The final draft consisted of 40 items instrument was later administered as a trial-test to (20) twenty SSII students, that comprised 11 males and 9 females that were not from the participating schools and not within the selected local governments. The result of the trial-test was used to determine the difficulty index of each test item, which ranges from 0.35 (35%) to .73 (73%). Based on this, only thirty (30) items of moderate difficulty levels were selected from final draft of 40 items drawn for the test. The reliability coefficient of 0.75 of the instrument was obtained using Kuder Richardson formula 20 (KR 20).

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 Achievement Test (SMAT) and Numerical Ability Test (NAT); 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 identified 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 actively reviewed at the commencement, during and at the conclusion of the lesson relevant previous topic that could enhance the understanding of the new topic. The teachers for the control group were not provided any material. They followed the conventional method of instruction. The thirteen week was used for conducting the post-test in respect of SMAT.

Method of 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 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.

Ho.1 – There is no significant main effect of treatment on students' achievement in mathematics.

Table 1: ANCOVA table showing the significant main and interaction effects of Treatment groups, Numerical Ability and Gender on the Pre-Post Achievement Test in Mathematics.

Source	Sum of Squares	DF	Mean Square	F	Sig.	Remark
Corrected Model	3326.340	18	184.797	12.083	.000	
PRETEST	137.045	1	137.045	8.961	.003	
Main Effect:						
TRTGRP	121.438	2	60.719	3.970	.020	Sig.
NA	882.645	2	441.323	28.856	.000	Sig.
GENDER	406.091	1	406.091	26.552	.000	Sig.
2-way Interactions:						
TRTGRP*NA	51.410	4	12.853	.840	.501	n.s.
TRTGRP*GENDER	73.379	2	36.690	2.399	.093	n.s.
NA*GENDER	69.657	2	34.829	2.277	.105	n.s.
3-way Interactions:						
TRTGRP*NA*GENDER	60.767	4	15.294	.993	.412	n.s.
Error	4114.104	269				
Corrected Total	7440.444	287				

The result from table 1 shows that there is a significant main effect of treatment on students' achievement in mathematics ($F_{(3,269)}$ = 8.961, P < .05). This implies that there is a significant difference between the achievements of students exposed to mnemonic and prior knowledge instructional strategies and the Convention Teaching Method. Therefore, the null hypothesis is rejected. Table 2 presents the multiple classification analysis (MCA) of the means scores of students' achievement in mathematics based on experimental and control groups

Table 2:Multiple Classification Analysis (MCA) showing the direction of the difference in the analysis: Achievement in Mathematics

Variable + Category Grand Mean = 13.86	N	Unadjusted variation	Eta	Adjusted for independent + covariates deviation	Beta
Treatment Group: 1. TRT I 2. TRT II 3. Control	 87 92 109	 3.05 -.80 -1.76	.40	 1.44 -.12 -1.05	.20
Numerical Ability: 1. Low 2. Medium 3. High	 82 85 121	 3.79 -.20 -2.42	.50	 3.17 -.47 -1.82	.41
Gender: 1. Male 2. Female	 96 192	 1.62 -.81	.23	 1.82 -.91	.25

MD. = Mean Deviation

From table 8, the mean scores of the different Treatment Groups show that Mnemonics Instruction has the highest mean score of 16.91, followed by Prior knowledge instruction 13.07, while Conventional Teaching Method obtained 12.10.

Table 3: Scheffe Post-Hoc Pairwise significant differences among the various groups of independent variables on the Achievement in Mathematics between the Treatment groups

Treatment Group	(I) Treatment Groups	(J) Treatment groups	Sig
Post test Achievement	Treatment I	Treatment II Control	.000 .000
	Treatment II	Treatment I Control	.000 .348
	Control	Treatment I Treatment II	.000 .348

The table above shows that there is a significant difference between Treatment I and Treatment II, Treatment I and Control respectively.

From the results, Mnemonic Instructional Strategy was superior to both Prior Knowledge Instructional Strategy and the conventional method of instruction as it obtained the highest mean score. However, Prior Knowledge also proved superior to conventional method of instruction. This was in line with Mastropieri, Scruggs, Levin, Gaffney and McLoone (1985) who observed that the reason comprehension scores were higher for students using mnemonic strategies was that the strategy increased their ability to recall factual information needed to answer comprehension questions. Through the use of mnemonic strategy, it is more likely that the students will be able to remember factual information, answer questions, and demonstrate comprehension. Also, Fontana, Scruggs and Masropieri, (2007), reported that when asked about their preferences for instructional strategies, the majority of students preferred mnemonics instruction; they felt they learn more, and would prefer to use mnemonic instruction in other content areas. On why Prior knowledge was superior to Traditional method of instruction, Hayes and Tierney (1982) found that presenting prior knowledge information related to the topic to be learned helped the readers learn more from texts regardless of how that prior knowledge was presented or how specific or general it was. Thus, Kopcha (2005) concludes that high prior knowledge students have the tendency to achieve better when they receive the type of control they prefer, while the opposite is true for low prior knowledge students.

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

The result from table 1 shows that there is a significant main effect of numerical ability on students' achievement in Mathematics ($F_{(3,269)} = 28.856$, $P < .05$). This indicates that there is a significant difference between Low Ability, Medium Ability and High Ability on Students' Achievement in Mathematics. Hence, the hypothesis is rejected. Table 2 (MCA) shows that low numerical ability obtained the highest mean score of 17.65, Medium mental ability 13.66, and High numerical ability 11.44. The results of the study revealed that numerical ability has significant effect on students' achievement in mathematics, with high numerical ability obtained the highest mean scores, and medium and low numerical ability follow in that order. This implies that student numerical ability determines mathematics achievement that is the higher the students' numerical ability the higher the achievement in mathematics. This coincided with the findings of Olowojaye (2004) and Arowolo (2010) who reported significant difference in mathematics achievement based on students' numerical ability.

Ho.3: There is no significant main effect of gender on students' achievement in Mathematics.

Table 1 shows that there is a significant main effect of gender on students' achievement in Mathematics $F_{(2,269)} = 26.552$, $P < .05$). The implication is that there is a significant difference in Male and Female Students' Achievement in Mathematics. Hence, the hypothesis is rejected. Table 2 (MCA) further shows magnitude of the mean score of male 15.48 higher than female 13.05. Though there is a difference, but the difference is not significant. Findings from the results showed that gender had significant main effects on students' achievement in mathematics. The result indicated that male students performed better in achievement test than female. This might implies that male students found the strategies easy and were able to implement the strategies than their female counterparts. This result was in line with Raimi and Adeoye (2002), Olowojaiye (2004) who reported significant difference in favour of male students. Furthermore, the result was contrary to Badiru (2007), Okigbo and Oshafor (2008), and Akinsola and Ifamuyiwa (2008), who reported no significant difference in students' achievement in mathematics.

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

Table 1 shows that there is no significant interaction effect of treatment, numerical ability and gender on students' achievement in Mathematics ($F_{(18,269)} = .993$, $P >.05$). 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 at improving the students' achievement Mathematics. The results revealed that Mnemonic Instruction had the higher mean score than both the Prior Knowledge and the Conventional Teaching method. The reason is that Mnemonic Instruction enables 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 improve their 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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