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Predicting Academic Success of Junior Secondary School Students in Mathematics through Cognitive Style and Problem Solving Technique

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Abstract
This study examined the prediction of academic success of Junior secondary school mathematics students using their cognitive style and problem solving technique. A descriptive survey of correlation type was adopted for this study. A purposive sampling procedure was used to select five Public Junior secondary schools in Ijebu-Ode local government area, Ogun state. For the purpose of this study, an arm of intact class JSSII students were selected from each selected school through a simple random sampling procedure. Three valid and reliable instruments were used to collect data for this study as Sigel's cognitive style test (SICOST), Problem solving technique test (PSTT) and Mathematics achievement test (MAT). Their content validity values were 0.79; 0.74 and 0.84 respectively using Lawshe method. The test retest reliability value was 0.82 of SICOST, the coefficient of reliability values of PSCT and MAT were 0.79 and 0.87 respectively using Kuder-Richardson (K-R 20)'s formula. The results of the Pearson correlation and Multiple regression test show that: no significant relationship exists between the students' cognitive style and problem solving technique; the two predictor variables jointly significantly predicted academic success in mathematics; the relative effect of problem solving technique in mathematics is greater than that of cognitive style.
It is recommended that problem solving intervention strategies should be used in handling the mathematical problems of students to enhance their academic success in other to serve as essential ingredients for achieving a holistic education.
Keywords: Academic success, Cognitive style, and Problem solving technique

Introduction

The origin of mathematics may have been human's attempt to solve certain quantitative problems of daily life. Today, there have been different definitions and different ideas expressed about mathematics. Oyedeji (2000) described it as a creative language, a tool, an art and a process. Ojo (2002) defined mathematics as the study of size, numeration and the relationship between them. Mathematics is made up of intellectual skills and rules which are sequential in nature (Ifamuyiwa, 1998). This implies that for any content area or topic in mathematics, there are always essential step to follow in the acquisition of knowledge of intellectual skills. Attempts to skip essential skills in mathematics can lead to bad consequences for it creates gaps in the knowledge of the skills and hence, hinders problem solving ability in students. Much of the subject that is known as mathematics today is an outgrowth of thought that was originally built around the concepts of number, magnitude and form. Rather, mathematics is now seen as the science of space and quantity, the knowledge of which is basic to all branches of sciences and technology (Tella, 2007).

Inspite of important place of mathematics in our educational system, students in secondary schools still register continually poor results at senior secondary certificate examination (SSCE) and in other external examinations. The poor performance is evident in the result in mathematics for May/June Senior Secondary School Certificate Examination (SSCE) WAEC from 2000-2012 as shown in table 1. From the table, out of 634,604 candidates who sat for the examination in 2000, only 208,244 representing 32.81% had between A1 to C6 in mathematics and these are the only candidates who could use the result to advance to tertiary institutions provided they have credits in other subjects relevant to their proposed course of study. On the other hand, in the same year 2000, 196,080 (30.90%) candidates had between D7 to E8. Therefore, it is submitted that these categories of students with D7, E8 and F9 totaling 426,360 (67.19%) cannot be given admission into tertiary institution to read mathematics related courses. The achievement of students fluctuated from 2000 until 2006, when the percentage of candidates with (A1 – C6) increased from 42.32% to 47.85% in 2007 and then increased again to 58.24% in 2008. In subsequent years, the percentage of students with credit pass in mathematics dropped from 58.24% in 2008 to 49.0% in 2009 and further dropped to 41.50% in 2010 and also, no significant improvement is recorded in the year 2011 and 2012.

Table 1: Analysis of Result in Mathematics for May/June Senior Secondary School Certificate Examination (WAEC) from 2000-2012 in Nigeria.

Year	Total Entry	No. of candidates that sat for the exam	No. of candidates with Credit (A1-C6)	Number of candidates with Pass (D7-D8)	No. of candidates with fail (F9)
2000	637,266	634,604	208,244 32.81%	196,080 30.90%	230,280 36.38%
2001	1040177	1,023,102	373,955 36.55%	334,907 32.73%	314,240 30.72%
2002	925288	908,235	309,409 34.07%	308,359 33.95%	290,457 31.98%
2003	1038809	903,154	341,928 37.86%	331,348 36.69%	229,878 25.45%
2004	1035266	832,689	287,484 34.52%	245,071 29.43%	300,134 36.05%
2005	1,054,853	1,033,440	402,954 38.99%	267,511 25.89%	362,975 35.12%
2006	1170523	1,116,638	472,583 42.32%	357,310 32.00%	286,745 25.68%
2007	1270136	1,220,425	583,921 47.85%	333,740 27.35%	302,764 24.80%
2008	1292890	1,247,282	726,398 58.24%	302,226 24.23%	218,618 17.53%
2009	1373009	1,294,755	634,382 49.00%	344,635 26.61%	315,738 24.39%
2010	1431557	1,351,557	560,974 41.50%	450,224 33.32%	340,359 25.18%
2011	1300425	1,220,425	583,921 47.85%	333,740 27.35%	302,764 24.80%
2012	1103102	1,023,102	373,955 36.55%	334,907 32.73%	314,240 30.72%

Source: Statistics Office, West African Examination Council, Lagos, Nigeria (2012)

The analysis of SSCE results from 2000-2012 shows that the performance of students in mathematics is still below expectation. Although, the performance of candidates seems to improve in some years, but the improvement is not significantly sufficient to conclude that students have mastered mathematics to the desired level. One can therefore say that despite the importance of mathematics, students' performance in the subject is still not encouraging. This problem of low achievement in mathematics could adversely affect national development, especially in science and technology. Ifamuyiwa (2008) indicates that the mass failure and consistent poor performance in mathematics which students have shown for several years now casts serious doubt on the country's high attainment in science and technology. Therefore, this situation cannot be allowed to continue without check.

Some renowned educators have always pointed accusing fingers to some reasons for the students' poor achievement in mathematics. For instance, Alio and Harbor-Peters (2000) viewed teachers' incompetent as a contributing factor. Kuku (1989) attributed his reasons to the low quantity of mathematics teachers produced by our tertiary institutions while Alio and Harbor-Peters (2000) and Imoko and Agwagah (2006) attributed their own reason to the teacher's non-utilisation of appropriate teaching techniques. Many teachers in schools use only techniques they know even if such techniques are not relevant to the concept under discussion (Akinsola & Popoola, 2004). Alio (1997) stated that teachers non-utilisation of the necessary technique in teaching mathematical problem solving is another contributing factor to the students' poor performance among other reasons.

A problem-solving model is a systematic approach that reviews student strengths and weaknesses, identifies evidence-based instructional interventions, frequently collects data to monitor student progress, and evaluates the effectiveness of interventions implemented with the student. Problem solving is a model that first solves student difficulties within general education classrooms. It gives students opportunities to study mathematics as an exploratory, dynamic, evolving discipline rather than as a rigid, absolute, closed body of laws to be memorized. They will be encouraged to see mathematics as a science, not as a canon, and to recognize that mathematics is really about patterns and not merely about numbers. If problem-solving interventions are not successful in general education classrooms, the cycle of selecting intervention strategies and collecting data is repeated with the help of a building-level or grade-level intervention assistance or problem-solving team

(Reschly & Tilly, in Andrea Canter, 2004; Marston, 2002). Erinosho and ogunkola (2005) asserted that problem-solving technique is a very good way of stimulating intellectual curiosity, which will eventually leads to acquisition of new knowledge. The technique involves identifying and choosing mathematical problems within the learners' experiences, placing these problems before the students and guiding them towards their solutions. The techniques allow students to learn from their successes and failures and this culminate into real comprehension of facts since it permits the students to participate in their learning. This implies that the technique s encourage students to think for themselves. Problem solving bridges the gap between a problem and a solution by using information (knowledge) and reasoning (Frazer in Ahiakwo, 1991).

Some studies such as Tella (2007); Abimbade (1987); Akinboye (1987) and Chacko (1981) have considered Piaget's various levels of cognitive development involving concrete and formal operational stages of students, as factors which could influence their problem solving behaviours. But the rationale for mathematics curriculum prescription as to what students can do or cannot do have been criticized (Salami, 2004; Ifamuyiwa, 1998 and Goodenough, 1976). Perhaps in the light of these criticisms, other alternative psychological factors could be examined to see what extent they are able to rationalize the difficulties students have with problem solving and learning in general

One of such factors involves students' preferences or styles of coping with cognitive activities that is, the ways they learn and this has to do with the individual's cognitive style. The concept of cognitive style is simply associated with and arises from the area of psychology known as psychological differentiation. By this is meant that differences exist between individuals in relation to their psychological functioning. Where such psychological functioning appears to take place in stable or relatively stable modes, certain characteristics/ styles may be ascribed to it (Abimbade, 1987). Cognitive style refers to an individual's way of perceiving and processing information. Cognitive style is defined as the way a learner organizes filters, transforms and processes information (Oyedeji, 1997; Arigbabu, 1995 and Perry & Penner, 1990). It is composed of variables related to have how we think, how we feel and how we sense or acquire input; that is a person's cognitive style is a pattern of strategies that are used to resolve problems including learning which is determined by the way in which a person takes in the environment or subject in which he/she is embedded (Bilesanmi-Awoderu, 2004 and Olagunju, 1994). Cognitive style is a term used by cognitive psychologists to describe the way individuals think, perceive and remember information or their preferred approach to using such information to solve problems (Oyedeji, 1994). Moreover, cognitive style is concerned with the ability to categorise stimuli ability to concentrate on the target stimuli amidst other distracting stimuli and identifying the simple from the complex within an individual's cognitive field or range of perception. It also concerned with the perceiving stimuli either in part or in whole, being analytic in our perception, style. It also defined as the ability to time out response to perceived stimuli associated with whether we are reflective or impulsive as regards our response to target stimuli (Oyedeji, 1997 and Gagne, 1977.

Therefore, this study sought to determine the extend to which cognitive styles and problem solving technique would predict academic success of Junior secondary school mathematics students. To this extent the following questions were generated:

i. Is there any significant relationship between students' cognitive style and problem solving technique in mathematics?
ii. To what extent would problem solving technique and cognitive style jointly predict students' academic success in mathematics?
iii. What is the relative contribution of the variables to the prediction?

Method

Research type: A descriptive survey of correlation type was adopted for this study.

Sampling techniques and sample: A purposive sampling procedure was used to select five Public Junior secondary schools in Ijebu-Ode local government area, Ogun state. For the purpose of this study, an arm of intact class JSSII students were selected from each selected school through a simple random sampling procedure. JSSII students were chosen because they are not being prepared for any external examination that might distract their attention from full participation in the study.

Instrumentation: Three valid and reliable instruments were used to collect data for this study as follows:

Sigel's cognitive style test (SICOST): The SICOST developed by Sigel and modified by Onyejiaku (2000) to reflect the Nigerian environment was used for this study and was adopted by the researcher. The instrument consisted of twenty cards numbered 1-20 with each card containing three pictures of which two of them could have one thing or another in common. Lawshe method was used to determine the content validity value t o be 0.79. The test retest reliability value was 0.82 (N=30).

Problem solving technique test (PSTT): This consisted of 5 item questions in General arithmetic which was broad topic in JSSII mathematics syllabus. Scoring of the test was based on the different stages of the Ashmore (1979) problem solving model as follows: defining the problem; selecting information from the problem statement (data); selecting information from the memory; reasoning; and computation. Lawshe method was used to determine the content validity value to be 0.74. The coefficient of reliability value was 0.79 using Kuder-Richardson (K-R 20)'s formula, N=30.

Mathematics achievement test (MAT): This was a 20 item multiple choice objective test with options A-D, developed by the researcher. The items covered the topics taught such as Algebraic processes and Trigonometry in the selected schools. Its content validity was established by drawing the blue print, and item analysis (Range values of Difficulty and Discriminating indexes were between 0.4 and 0.7), Lawshe method was used to determine the content validity value to be 0.84 and the coefficient reliability value was computed to be 0.87 using Kuder-Richardson (K-R 20)'s formula, N=30.

Data collection: After due permission has been granted by the school authority, the researcher with the cooperating teachers assembled the students in a classroom for about 1 hour. The three instruments were administrated simultaneously to the students and collected immediately.

Data analysis: Data collected were analysed using Pearson correlation and Multiple regression analysis.

Results and discussion

Research question 1: Is there any significant relationship between students' cognitive style and problem solving competence in mathematics?

Table 2: Relationship between cognitive style and problem solving technique in Mathematics

Variables	Problem solving technique
Cognitive style Pearson correlation	0.014
Significant (2-tailed)	0.868
N	150

$P > 0.05$

The result in table 2 shows the Pearson correlation value of 0.014 between the students' cognitive style and problem solving technique in mathematics. Since the significant value of 0.868 is greater than significant level of 0.05. Therefore, the value of correlation obtained is not significant. This implies that there is no significant relationship between the students' cognitive style and problem solving technique in mathematics. Hence, it can be concluded that the two variables are independent. This outcome is in line with the findings of Ahiakwo (1991) who found out that cognitive style does not have any direct influence on subject's performance with problems that are content dependent. Also, he reported that cognitive style has more to do with the processes, the ways by which knowledge is acquired rather than with the content of subject matter itself.

Research question 2: To what extent would problem solving technique and cognitive style jointly predict students' academic success in mathematics?

Table 3: Regression summary of cognitive style and problem solving technique explaining academic success in mathematics.

Multiple R = 0.23
R Square (R^2) = 0.05
Adjusted R^2 = 0.04

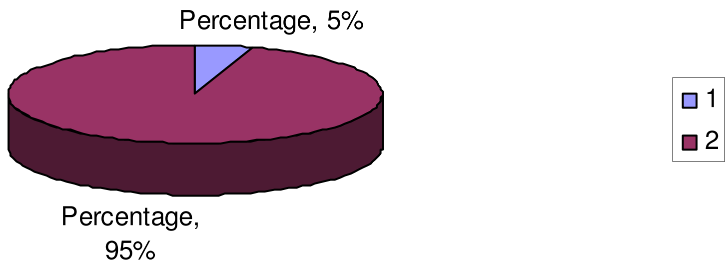
Source of variation	Df	Sum of square	Mean square	F ratio	Sign value
Regression	2	194.84	97.42	3.99	0.02*
Residual	147	3586.25	24.40		
Total	149	3781.09			

* = Significant ($p < 0.05$).

Table 3 indicates that the cognitive style and problem solving technique to predict academic success in mathematics yielded a coefficient of multiple regression (R) of 0.23 and multiple regression square (R^2) of 0.05. The table also shows that Analysis of Variance (ANOVA) of the multiple regression data yielded an F-ratio value of 3.99 at significant level of 0.05. It is observed that F-ratio value is significant at the 0.5 confidence level. This indicates that the effectiveness of a combination of the independent variables in predicting academic success in mathematics could not have occurred by chance. It may thus be said that about 5.0% of the total variability in academic success in mathematics is accounted for by a linear combination of the cognitive style and problem solving technique (1). While the remaining 95% or these about are due to other variables (2) not considered in this study which can be illustrated in figure 1.

The link between the predictor variables on one hand and academic success on the other is explicable if considered carefully, the submission of the behavourist psychologists (Onyejiaku, 2000; Gagne, 1997 and Maslow, 1971) that learning is an individual thing. To this end, the researcher contends that whatever the opportunities available, a student learns because she/he has made up her/his mind to learn coupled with the fact that such decision is influenced by his/her personal/inherent characteristics.

Figure 1: Percentages of contribution



Research question 3: What is the relative contribution of the variables to the prediction?

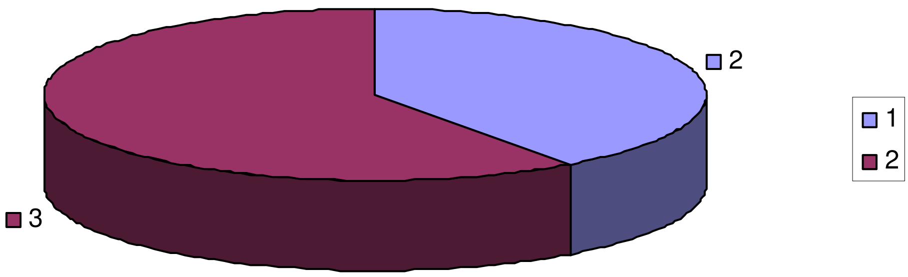
Table 4: Relative contribution of each of the predictor variable

Var. no	Description	R^2	Beta	t-value	Sign. Value
1	Cognitive style	0.02	0.15	2.21	0.03*
2	Problem solving technique	0.03	0.16	2.06	0.04*

*= Significant ($p < 0.05$).

To respond to research question 3 which seeks to determine the relative contribution of each of the predictor variable to prediction, the data shows that the beta value of the problem solving technique (0.16) is greater than cognitive style (0.15) as shown in table 4. According to table 4, Cognitive style alone explains about 2% ($R^2 = 0.02$); and Problem solving technique alone explains about 3% ($R^2 = 0.03$) of the variance in the performance of students. The picture of each of the predictors in percentages on the performance of students taught as illustrated in figure 2. One explanation of this is that the increase in students' ability to connect new information to existing relevant concepts in the learner's cognitive structure led to an increase in students' ability to solve problems. Thus, the results of the study reveal that students' academic success in mathematics would greatly improve if relevant methods are applied. This supports Ezeugo & Agwagah (2000) who reported that teaching method is a major contributory factor to students' achievement in mathematics. It also confirmed with those of Kalejaiye (2011); Adeagbo (1985); Arigbabu (1995) who documented significant effect of problem solving competence on students' learning outcomes. Furthermore, Olayinka (1983) found out that problem solving approach of teaching word problems in simultaneous equations is more effective than the conventional method.

Figure 2: Relative contributions



Implications and conclusion

This study has established the fact that there is no significant relationship between cognitive style and problem solving technique in Junior secondary school mathematics. It found that the cognitive style and problem solving technique of students significantly predicted academic success in mathematics when taken together. The findings from this study have some implications for teachers of mathematics and their students in our schools. There is need for mathematics teachers to include problem solving technique as part of the predictor variables when studying academic success among the secondary school students since it correlated with academic success. Also, mathematics teachers should include problem solving techniques as part of their intervention strategies when they are teaching the students in the classroom. It is recommended that problem solving intervention strategies should be used in handling the mathematical problems of students to enhance their academic success in other to serve as essential ingredients for achieving a holistic education. This is because the problem solving model involves the learning of social, cognitive as well as affective skills which are all crucial to success at school.

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