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Impacts of Reasoning Ability on Performance and Retention in Trigonometry among Senior Secondary School Students in Katsina State, Nigeria.

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Abstract

This study investigated the impacts of reasoning ability on performance and retention ability in trigonometry among Senior Secondary School Students in Katsina State, Nigeria. Repeated design of correlational survey research method was used. Three hundred and seventy four (374) sampled students were used selected from a total population of sixteen thousand one hundred and forty one (16,141) students in the study area using stratified and simple random sampling technique. Trigonometric Performance Test (TPT), Trigonometric Reasoning AbilityScale (TRAS) and Trigonometric Retention Test (TRT) with reliable co-efficients of (r) = 0.93, 0.89 and 0.85 respectively were used as instruments for data collection. The data collected were analyzed using mean and standard deviation in order to analysed the data. However, Pearson Product Moment Correlation Co-efficient was used to test the formulated hypotheses at p≤ 0.05 level of significance. Result showed 0.95 and 0.92 as correlation coefficients between reasoning ability and performance andreasoning ability and retention ability of students in trigonometry respectively. This means 90% in performance was accounted for reasoning ability of students in trigonometry and 85% in retention ability was attributed to reasoning ability of students in trigonometry. Hence, reasoning ability significantly affect the performance and retention ability of students in trigonometry in particular and mathematics in general. Based on these findings, it was recommended that: teachers and educational planners should consider reasoning ability of students in teaching and learning for effective teaching and learning to take place.

Introduction

Expert in science education leveled mathematics as a king and bedrock of all sciences.Therefore, the use of mathematics knowledge spreads across all spheres of human endeavor and as such, there is no subject, field of study or any profession that does not makes used of some form or order of mathematics,it is compulsory for all secondary school students and a pass at credit level in ordinary level mathematics examination is one of therequirements for gaining admission in any tertiary institution to study science related and mathematics course.Hence, recognition attached to it cannot be over emphasized. Unfortunately, despite all the relative importance of mathematics in science and other field of studies, students' performance in the subject has remained constantly poor (Adolphus, 2011). Also,Udoh (2011) reported that,many students find it difficult to solve mathematical problems among which is the trigonometric problem which no doubt constitutes an educational problem with serious implication.Table 1. concretized all the above reports about poor performance of students.

Table 1: Performance of Students inMathematics WASSCE in Katsina-State.

Years	No. Registered	No. withcredit	No. with pass	No. Failed	No. Pending
2013	15,010	6004 (40%)	4803(32%)	3587(24%)	616(4%)
2014	15,250	6405(42%)	5338(35%)	3355(22%)	152 (1%)
2015	15,500	6665(43%)	5270(34%)	3100(20%)	465(3%)
2016	15,750	6930(44%)	5670(36%)	2993(19%)	157 (1%)
2017	15,900	6837(43%)	6042(38%)	2226(14%)	795(5%)
2018	16,020	6408(40%)	6248(39%)	1652(10%)	1712(11%)

Source: Test and Statistics, Ministry of Education,Katsina(2019).

Based on such low performance of students in mathematics WASSCE that KajuruandKauru (2010) reported that performance of studentshas becomes a source of concern in mathematics education. Hence, this may lead to various misconceptions of students' performance in trigonometry in particular and mathematics in general.The reasons for such poor performance and retention of students in trigonometry in particular and mathematics in general are associated with many factors such as lack of qualified mathematics teachers, misunderstanding of the mathematics concepts, inadequate instructional materials, lack of incentives to the available qualified teacher, teachers' attitude, peer group influence students' attitude, strategies of teaching, problem of choice of instructional methodologies that fit neatly not only the topics but also the learners' conceptual understanding, emotional intelligence, reasoning ability, self-efficacy and so on (Bolaji in Olabisi, 2011; Sirajo, Mari &Olorukooba, 2013). But, for the purpose of this study, the researcher restricted to only emotional intelligenceof students.

Reasoning is the process of thinking in a logical way. Reasoning ability therefore, is the ability to accurately understand a situation, acknowledge their subjective interpretation of the situation, and reach a logical conclusion based on this supporting knowledge. It is also the ability to derives conclusions from preexisting premises and make a rational decision (judges) truthfulness of statement through normative logic (e.g.If A=B andC=B. Therefore,A=C). In a research conducted by Lavins (2011) indicated that students who have acquired high formal reasoning ability retain and perform better, have deep working memory that enable them solve abstract problems in logical manner and also able to apply scientific thinking in solving problems such as stating testing hypotheses, differentiate variables,

analyzing data, ability to keep concepts and their interrelationships in the mind while considering answers.

Statement of the Problem

Despite all the relative importance of mathematics in science subjects and other field of studies or professions, students' mathematics performance in WASSCE has remained constantly poor. However,WASSCE Mathematics Chief Examiners' Reports (2015-2017) reported that questions on trigonometry were poorly attempted by the candidates which contribute toward poor performance of studentsin mathematics in general.In an attempt to possibly promote the performance andretention and equally solve the problems of poor performance and retention ability of studentsin trigonometry in particular andmathematics in general,reasoning ability of studentswasproposed to investigate itseffect onthe performance and retentionability level of studentsto see if it could address this problem or not.Therefore,thisstudy investigated the impacts of reasoning ability on performance and retention ability in trigonometry to know how much itcontributed toward performance and retention ability of students.

Objectives of the study

In specific terms, the objectives of this studywere to:

1. investigate the impacts of reasoning ability on performance scores of students in trigonometry.
2. determine the impacts of reasoning ability on retention ability level of students in trigonometry.

Research Questions

The following research questionsguided the conduct of this study.

1. Is there any relationship betweenreasoning ability and performance scores of students in trigonometry?
2. Is there any relationship between reasoning ability and retention ability scores of students in trigonometry?

Null Hypotheses

The following null hypotheses were formulated and tested at $p \leq$ a constant alpha value of 0.05 level ofsignificance.

1. There is nosignificant relationship between reasoning ability and performance scores of students in trigonometry.
2. There is nosignificant relationship betweenreasoning ability and retention ability level of students in trigonometry.

Significance of the Study

It is hoped that, findings from this study will:

Provide mathematics teachers and students with relevant information about the impacts of reasoning ability on performance and retention ability level of students.

Help Educational Planners because the findings of this study as a research workprovidedinformation about the impacts ofreasoning ability on performance and retention ability level of students. Hence, this

helped them to plan the process and evaluation ofteaching and learningto cater for the diverse students in the school.

Contribute to the existing literatures because the findings of this study as a research work served as an eye opener, source of information and reference material that helped other interested researchers who may wish to conduct further research in related areas.

Assist State Ministries of Education, Mathematics Improvement Project (MIP) and Mathematics Association of Nigeria (MAN) among othersbecause the findings of this study as a research work could be known to public through conferences, seminars and workshops by MIP and MAN. **Scope / Delimitation of the Study**

This studycovered all publicco-educational senior secondary school students inKatsinaState. The justification for this is because seventy percent(70%) of public senior secondary schools in the state under study are operating as co-educational school, they aresimilar in terms of performance, number and quality of teachers,structures, and other instructional facilities (Katsina State Ministry of Education, 2017).In addition, only S.S.II students were used for this study because they were the most stable and were also neither introductory who were not settled for the study or familiar with the school, nor final year students who were busy with their final examinations. Also, the scopewas delimited toonly three cognitive levels (remembering, understanding and applying) because they allow for predetermined answers, were the most often multiple choice questions target and classified as convergent (Anderson & Krathwohl, 2001). Meanwhile, the scope was delimited to the following trigonometric concept areas;basic trigonometric ratios, angle of elevation and depression, bearing and distance and quadrants.

Basic Assumptions

This research work was conducted under the following basic assumptions that the:

1.students were exposed to basic trigonometric concepts.
2.Teachers have covered all the trigonometric concept areas as required.
3.sample of the study were true representative of the population to whom inference were made.

Research Design

The design used for this study was repeated design of correlational survey research method.It consist of only one group of similar students in terms of performance, number and quality of teachers, structures and other instructional facilities in which every participant in the study group was measured repeatedly using each of the threeinstruments (TPT, TRAS and TRT) in order to measure the performance, reasoning ability and retention ability of students in trigonometry respectively. However, the data of all the measures were correlated with Pearson Product Moment Correlation Co-efficient in order to find out if the reasoning abilityof students significantly affect the performance and retention ability of students or not.The research design is shown in figure 3.1

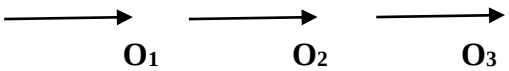

Figure 3.1

Where,

G = Group ofSample Students

O_1=First measure using TPT

O_2=Second measure using TRAS

O_3=Third measure using TRT

Population of the Study

At the time of conducting this research, there was a total number of ninety (90) public co-educational senior secondary schools with atotal number of sixteen thousand one hundred and forty one (16,141) students consisted of eleven thousand five hundred and sixty six (11,566) male and four thousand five hundred and seventy five (4,575) femalespread across all the thirty four (34) local government areas (LGAs) of the state. The details of the population distribution is presented in Table 2.

Table 2: Population Distribution by Zones, LGAs, Schools,Armand Gender.

	ZonesNo. of LGAs	No. of Schools	Numberof S.S.II Students Male	Female	PopulationSize
1.	Daura5	13	2,001	812	2,813
2.	Mani 4	11	1,543	674	1,217
3.	Katsina6	15	2,062	987	3,049
4.	Dutsin-ma5	12	1,598	529	2,127
5.	Kankia 5	13	1,072	215	1,287
6.	Malumfashi3	11	1,188	500	1,588
7.	Funtua6	15	2,102	958	3,060
	Total34	90	11,566	4,575	16,141

Source: Test and statistics, Ministry of Education,Katsina (2018).

Sample and Sampling Technique

A sample size of three hundred and seventy four (374) students was used in this study in line withResearch Advisor (2006) Table for Determination of Sample Size Guidelines.The details of the sample distribution is presented in Table 3.

Table 3: SampleDistributionby Zones, LGAs, Schools, Armand Gender.

ZonesName of LGAs	Name of Schools	Number ofstudents Male	Female	Sample Size.

KankiaMusawa	G.S.S Tsuntsaye	3511	46
DauraZango	G.S.SBaure G	4111	52
MalumfashiKankara	G.S.S Gurbi	3912	51
Dutsin-maDutsin-ma	G.S.S Karofi	4112	53
FuntuaDanja	G.S.S Kahutu and Tsiga	4622	68
KatsinaKatsina	G.S.S Kayoki	4818	66
ManiBindawa	G.S.S Giremawa	30 8	38
Total		28094	374

Source: Research Advisors (2006) Table for Determination of Sample Size Guideline.

Instrumentation

The following instruments were used to collect data.

1. Trigonometric Performance Test (TPT).
2. TrigonometricReasoning Ability Scale (TRAS).
3. Trigonometric Retention Test (TRT).

Trigonometric Performance Test (TPT)

This instrument wasan adapted version of WAEC and NECO standard sample trigonometric questions that were highly validated and found to be very reliable with an acceptablereliability index of 0.93in order to measure performance of students in trigonometry. The distribution of the items is presented in Table 4.

Table 4:Items Specification based on Revised Bloom Taxonomy of Educational Objectives of Trigonometric Performance multiple choice test.

Content Area	Rememb. (44%)	Understan. (36%)	Applying (20%)	Total
Basic trigonometric ratios (40%)	9 (6, 7, 8, 22, 24, 25,42,43 and 44)	8 (35, 36, 38, 40, 47, 48, 49 and 50)	3(41, 45 and 46)	20
Bearing and distance (22%)	5 (9, 10, 11, 12 and 28)	3 (13, 14 and 23)	3 (26, 37 and 39)	11
Angle of Elevation and Depression (24%)	6 (15, 16, 17, 18, 19 and 20.	3 (21, 27 and 29)	3 (30, 31 and32)	12
Four Quadrants (14%)	2 (33 and 34)	4(1,2,3 and4)	1(5)	7
Total	22	18	10	50

Source: Adapted from Anderson and Krathwohl (2001).

Trigonometric Reasoning Ability Scale (TRAS)

This instrument was an adapted version of Dweck General Mathematics Ability Scale (2000) with acceptable internal consistency and test-retest reliability index of 0.89 in order to measure reasoning ability of students. It has five (5) possible options ranging from Strongly Agree (number 5), Agree (number 4), Undecided (number 3),Disagree (number 2) to Strongly Disagree (number 1). Each option carries weight in order of priority from 5-1 in emotional intelligence positive responses of fourteen (14) items (7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19 and 20) but from 1-5 in emotional intelligence negative responses of six (6) items (1, 2, 3, 4, 5 and 6). The distribution of the items is presented in Table 5.

Table 5:Items Specification based on Taxonomies of Instructional Learning Target on Reasoning Ability Scale

Content Area	Knowledge and Understanding (50%)	Skills/Capability (20%)	Feelings/Attitude (30%)	Total
Correlation reasoning (30%)	3 (7, 9 and 17)	1(18)	2 (8 and 10)	6
Proportional reasoning (20%)	2 (3 and 5)	1 (6)	1 (4)	4
Combinatorial reasoning (10%)	1 (19)	0 (0)	1 (20)	2
Probabilistic reasoning (20%)	2 (11 and 13)	1 (15)	1 (12)	4
Controlling variable (20%)	2 (1 and 14)	1 (16)	1 (2)	4
Total	10	4	6	20

Source: Adapted from Nitko and Brookhart (2007).

Trigonometric Retention Test (TRT)

This instrument is parallel to trigonometric performance test (TPT) but differs only in their marking scheme because the figures, serial number and correct options of the items in trigonometric Retention test (TRT)were changed. The justification for this is to minimize examination malpractice since the marking scheme of trigonometric performance test (TPT) was known by the students. However, it has an acceptablereliability index of 0.85 in order to measure retention ability of students in trigonometry. The distribution of the items is presented in Table 6.

Table 6:Items Specification based on Revised Bloom Taxonomy of Educational Objectives of the Trigonometric Retention Multiple Choice Test.

Content Area	Rememb. (44%)	Understan. (36%)	Applying (20%)	Total
Basic trigonometric ratios (40%)	9 (2, 4, 5, 22, 23 24,36,37 and 38)	8 (15, 16, 18, 20, 27, 28, 29 and 30)	3 (21, 25 and 26)	20
Bearing and distance (22%)	5 (8, 39, 40, 41 and 42)	3 (3, 43, 44 and)	3 (6, 17 and 19)	11

Angle of Elevation and Depression (24%)	6 (45, 46, 47, 48, 49 and 50.	3 (1, 7 and 9)	3 (10, 11 and 12)	12
Four Quadrants (14%)	2 (13 and 14)	4(31, 32, 33 and34)	1(35)	7
Total	22	18	10	50

Source: Adapted from Anderson and Krathwohl (2001).

Validation

The validation of all the three (3) instruments used in this study:Trigonometric Performance Test (TPT), Trigonometric Reasoning Ability Scale(TRAS)and Trigonometric Retention Test (TRT) for qualitative items analysis (construct, face and content validity check)in order to ensure that the instruments are free from random and systematic errors.Before validation of the instruments, the number of items in the instruments (TPT, TRAS and TRT) used as initial draft in this study were eighty two (82), thirty (24) and eighty two (82) respectively but after validation of the instruments, the number of items in the instruments (TPT and TRT) used in pilot testing of the instruments were reduced from eighty two (82) tosixty (60) but that of the instrument (TRAS) remain unchanged.The justification for this was because they are the only test items that have been certified very relevant in measuring students' performance, retention andreasoning ability in trigonometry.

Reliability of the Instruments (TPT, TRAS and TRT)

The reliability of a research instrument refers to the capability of the instrument in obtainingthe same value when measurements are repeated. In this study, the reliability index of the instruments(TPT, TRAS and TRT) were obtained usingreliable statistics ofCronbach's alpha and Pearson Product Moment Correlation Co-efficient (PPMCC) by the aid of SPSS-16.0 version andfound to be 0.93, 0.89and 0.85 respectively.

Pilot Testing

The instruments used in this studywere pilot tested with a total number of thirty (30) S.S.II students of G.D.S.S Yari which is one of the schools in the study population but not in the sampled schools. The pilot testing was conducted under a very strict condition and no student was allowed to go out with the question paper in order to avoid leakage of the items in the instruments which may in turn affect the final test result. The purpose of pilot testing is torevalidate and determine the reliability of the instruments and the quality of the test items. Before pilot testing of the instruments, the number of items in the instruments (TPT, TRAS and TRT) used as initial draft in this study after validation were sixty (60), thirty (24) and sixty (60) respectivelybut after pilot testing of the instruments, the number of items in the instruments (TPT, TRAS and TRT) used as final draft in this study were reduced to fifty (50), twenty four (20) and fifty (50) respectively. The justification for this was becauseafter items analysis, they are the only tests items that were within an acceptable range value of Facility Index (F.I) and Discrimination Index (D.I).

Procedure for Data Collection

First, the researcherforwarded an introduction letter to Zonal Education Office and the principals of the seven selected schools for the sampling procedure to select classes and administering the instruments (TPT, TRAS and TRT). Secondly, RAs were invited by the researcher for a discussion and rehearsal about the content of the instruments in order to ensure further validation of the instruments. Each of the RAs was given a copy of all the instruments (TPT, TRAS and TRT) to scrutinize, ask questions, interact with colleagues and make criticisms for further improvement or adjustment on the instruments. The researcher was administered two (2) instruments (TPT and TRAS) to the sampled students as initial measurement in a normal class hours under the guidance of their mathematics teachers in order to measure the performance and emotional intelligence of students in trigonometry respectively.

Meanwhile, the researcher was also administered only one (1)instrument(TRT) to the sampled students as final measurement (retention test)with an interval of two (2) weeks afterinitial measurement in a normal class hours under the guidance of their mathematics teachers in order to measure the retention ability level of students in trigonometry because the researcher might have assumed that after two weeks, the students may have forgotten the items in the initial measurementas opined by (Usman, 2012).

Procedure for Data Analysis

Descriptive and inferential statistics wereemployed in the analysis of the data collected. In order to answer or analyzed all the research questions, descriptive statistics of means and standard deviations were employedbecause they provide a simple summary used to describe the basic features of the data collected drawn from sample. To test all the formulated Null Hypotheses, an inferential statistics of Pearson Product Moment Correlation Co-efficient (PPMCC)wasemployed at $p \leq 0.05$ level of significancebecause it is the most suitable statistical technique for testing significant relationship between two groups of values that are parametric in nature.

Research Question One (1)

Table 7: Means and Standard Deviations onReasoning AbilityandPerformance Scores of Students inTrigonometry

Variables	Perf.	R.A	N	Mean	Std.Deviation	Std. Error
Perf.	1.00		374	63.944	6.13215	0.38783
R.A	0.95	1.00	374	63.980	6.13205	0.38782

The results in Table 7. showed the mean performance andreasoning abilityscores of students are equal to 63.944 and 63.980 respectively. However, the coefficient of correlation between performance and reasoning ability scores of students is equal to 0.95. But, we cannot concludeabout the significanceof the correlationuntil the corresponding Null Hypotheses is tested.

Research Question Two (2)

Table 8: Means and Standard Deviations onReasoning Abilityand RetentionAbility Scores of Students inTrigonometry

Variables	Ret.	R.A	N	Mean	Std.Deviation	Std. Error
Ret.	1.00		374	60.790	8.34481	0.46453

R.A	0.92	1.00	374	63.980	6.13205	0.38782

The results in Table 8. showed the mean retention ability and reasoning ability scores of students are equal to60.790 and 63.980 respectively.However, the coefficient of correlation between retention and reasoning ability scores of students is equal to0.92. But, we cannot conclude aboutthe significance of the correlation until thecorresponding Null Hypotheses is tested.

Null Hypothesis One

Table 9:Pearson Product Moment Correlation Co-efficient onReasoning Ability and Performance ScoresofStudents in Trigonometry

Variables.	Performance Scores	Reasoning Ability
Performance Scores	r = 1.00	
	(p = 0.00)	
	r = 0.95	r = 1.00
Reasoning Ability		
	(p = 0.00)	(p = 0.00)

Significant at $p \leq 0.05$.

The results in Table 9. showed an observed P-value is equal to 0.00, at $\alpha = 0.05$ with degree of freedom of 373. This coefficient of correlation was found to be significance. Therefore, Null Hypotheses 1 wasrejected. Hence, there aresignificant relationships betweenreasoning ability and performance scores of students in trigonometry. However, according to Cohen (1988) and Musa (2016), the direction and the effect size of the relationshipswere classified as positively high.

Table 10:Pearson Product Moment Correlation Co-efficient onReasoning Ability and RetentionAbility Scoresof Students in Trigonometry

Variables.	Retention Ability Sores.	Reasoning Ability
Retention Ability Sores.	r = 1.00	
	(p = 0.00)	
	r = 0.92	r = 1.00
Reasoning Ability		
	(p = 0.00)	(p = 0.00)

Significant at $p \leq 0.05$.

The results in Table 10. showed an observed P-value is equal to 0.00, at $\alpha = 0.05$ with degree of freedom of 373. This coefficient of correlation was found to be significance. Therefore, Null Hypotheses 2 was rejected. Hence, there issignificant relationship between reasoning ability and retention ability scores of students in trigonometry. However, according to Cohen (1988) and Musa (2016), the direction and the effect size of the relationships was classified as positively high.

Findings

The major findings of the study were as follows:

1. There exists a high positive correlationcoefficient of 0.90 betweenreasoning ability and performance scores of students in trigonometry.
2. This study investigated a high positive correlation coefficient of 0.85 betweenreasoning abilityand retention ability of students in trigonometry.

Discussions of result

Based on the findings of this study, the discussions were as follows:

- Finding of this study showed the existing of a high positive correlation of r = 0.95 between reasoning ability and performance scores of students in trigonometry. This finding confirmed the studies of Nasir and Mansur (2009), Ameneh, Yahya,Tahereh, Mansour and Mohammad (2011), Azuka (2012), Azizi, Noordin, Boon, Hashim and Lee (2012), Fayombo (2012), Arokia, Maraichelvi and Sangeetherajan (2013), Arokiamaraichelvi and Sangeetherajan (2013), Hamdy and Aadeyemo, (2014) and Rice (2014) earlier found that,there exists a very high positive correlation betweenreasoning ability and performance scores of students. This may be because, they consider both male and female students.
- Finding of this study investigated a high positive correlation coefficient of 0.92 betweenreasoning ability and retention ability of students in trigonometry. This finding confirmed the studies of Nasir and Mansur (2009), Ameneh, Yahya,Tahereh, Mansour and Mohammad (2011), Azuka (2012), Azizi, Noordin, Boon, Hashim and Lee (2012), Fayombo (2012) and Rice (2014) earlier found that,there exists a very high positive correlation between reasoning ability and retention ability of both male and female students. This may be because, they consider both male and female students.

Conclusions

Based on the interpretation of the findings, the following conclusions were drawn:

1. Finding of this study showed that, the correlation coefficient and coefficient of determinant were 0.95 and 0.90 respectively betweenreasoning ability and performance scores of students in trigonometry which means that, 90% in performance is accounted for reasoning ability of students in trigonometry.
2. Finding of this study examined the correlation coefficient and coefficient of determinant as 0.92 and 0.85 respectively between reasoning ability and retention ability scores of students in trigonometry which means, 85% in retention ability is responsible for emotional-intelligence of students in trigonometry.

Therefore, reasoning ability has significantly positive impacts on performance and retention ability level of students in trigonometry in particular and mathematics in general.

Recommendations

This study established that, 90% and85% in performance and retentionability level of students respectivelyare accounted for reasoning ability.Based on these interpretations of the findings, the following recommendations were made:

1. Teachers should be able to consider reasoning abilityof students in teaching and learning.
2. Textbook publishers should publish textbooks that contain the guidelines and procedures for the use of reasoning ability of students in teaching and learning for better performance and retention of students.

3. Educational planers should emphasize the used of reasoning abilityin teaching and learning for better performance and retention of students in trigonometry in particular and mathematics in general.
4. Ministry of Education in collaboration with Mathematics Improvement Project should organize workshopsaim at educating teachers on how to usereasoning abilityof students in teaching.
5. Parent teachers Association and Non-Governmental Organization should be able to provide instructional materialsthat contain the guidelines and procedures for the use of reasoning ability in teaching.

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