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Students' Mathematics Achievement and Quantitative Reasoning Ability in Junior Secondary Schools in Rivers State Nigeria

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Abstract Aptitude tests are used globally for academic admission and job placement. This study, therefore, employed the correlational research design to investigate the relationship between students' Mathematics achievement and quantitative reasoning ability in junior secondary schools in Rivers State Nigeria. Three objectives, three research questions and three null hypotheses were tested at 0.05 alpha level. The population was 1, 853 junior secondary school three (JSS3) students in the public co-educational junior secondary schools in Asari-Toru Local Government Area of Rivers State, Nigeria. A 2-stage simple random sampling technique was used to select a sample of sixty-one students. Two validated and reliable instruments titled Mathematics Cognitive Achievement Test (MCAT; r =0.81) and Quantitative Reasoning Ability Test (QRAT; r =0.73) were used to collect data. All the sample students were taught some selected Mathematics topics and how to observe, identify patterns and apply basic mathematical skills to resolve quantitative reasoning test items. Mean, standard deviation and Pearson Product Correlation was used for analysis. The result showed that there is a moderate positive relationship between students' Mathematics achievement and their quantitative reasoning ability. Gender wise, the result revealed that there is a moderate positive relationship between the female students' Mathematics achievement and their quantitative reasoning ability while there is a positive fair relationship between the male students' Mathematics achievement and their quantitative reasoning ability. It was therefore recommended amongst others that quantitative reasoning should be learnt in schools as a subject on its own to allow more time for grooming of its skills and processes.

Keywords: *mathematics achievement, quantitative reasoning, correlation, student*

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1. Introduction

Mathematics has often been described as a language of quantities, whether the quantities are in numbers, dimensions of shapes, variables or a mixture of these. Sometimes, these shades of quantities qualify each other or set conflicts that need to be resolved to understand the language spoken in quantities. Achieving harmony that is consistently applied in all situations is to rise above the threshold of abstracts into proper quantitative reasoning which elicits understanding, interpretation and eventual fluency in the language of quantities. Perhaps the most important aspect of language is its understanding. The ability of a student to understand a mathematical problem is already an achievement and also the ability of a student to recognize or reason out a quantitative problem is another level of achievement.

Mathematics is an important and compulsory subject in the educational system. The reason has being that its application cuts across all areas of human endeavour. One of the objectives of teaching Mathematics in the school is to develop the computational skills and logical reasoning ability of students. Ali [1] asserted that Mathematics is a subject that entails problem-solving. This may suggest why Oringanji [2] opined that Mathematics prepares students to resolve a myriad problem solving, be it in the classroom or outside the classroom. Fayose & Loyd [3] posited that Mathematics is the language of quantitative reasoning.

Quantitative Reasoning (QR) is an aspect of problem-solving that engages students to reason quantitatively by observing patterns and making meanings out of the pattern using the basic mathematical algorithm. Quantitative reasoning utilizes more of pattern observation in a given sample and application of basic mathematics skills to solve problems. Babatunde [4] posited that the quantitative reasoning ability of students is tested in quantitative aptitude test in their common entrance examination, the final selection of candidates after qualification and job placement. Students are expected to exhibit their quantitative reasoning ability which is different from Mathematics ability in any aptitude test, Collins [5].

Anyanwu [6] carried out a study on the challenges pupils encounter in carrying out QR problems in State Common Entrance Examination in Ebonyi State Nigeria. The result of the study showed that public primary school pupils are not exposed to QR during classroom instruction while private primary school pupils are exposed to QR by learning it as a separate subject. Oluwaseun [7] in his study found out that a high percentage of primary school pupils, secondary school students, university students and even job seekers who are subjected to Aptitude Test (AT) perform poorly. Reason has been that they see AT as a higher Mathematics meant for the elite without knowing that what is required of them in AT is pattern recognition, basic arithmetic processes and higher mental cognition to reason out the relationship in the sample.

Habib [8] identified four essential components of QR as engagement with real-life situations, ability to observe the sample pattern, ability to apply the observed pattern quantitatively to novel situations and ability to adapt quantitatively in the midst of insufficient or irrelevant information. Quantitative reasoning cuts across so many topics in Mathematics. For instance, roman numerals, basic operations, charts, patterns and designs, mixed operations, missing numbers, number code, magic square, proportion etc. The importance of AT in educational and job placement makes it imperative for students to be exposed to QR and be put through the necessary skills needed for engagement in AT. The exposure to QR should not be tilted towards a pinch of salt at the end of chapters in Mathematics texts since this does not give room for teachers and students to delve into the required skills to tackle QRT. It is fundamental that students be put through the skills needed for quantitative reasoning tests since such tests are what most institutions use for placement. Ekpomana [9] posited that QR is not the same as Mathematics but rather basic mathematical processes (although not sufficient) is what students require to excel in AT. The QR teacher, therefore, needs to structure the learning process to establish to students the relationship between QR ability and Mathematics ability. Egwunwa [10] succinctly stated that a high achiever in Mathematics may not necessarily possess a high ability in QR. This study, therefore, sought to investigate the relationship between students' Mathematics achievement and quantitative reasoning ability in junior secondary schools.

1.1. Statement of the Problem

Students study Mathematics as a compulsory subject in both primary and secondary levels of education. At the tertiary institution, students are also required to offer a basic Mathematics course under the umbrella of General Studies (GNS). Reports and observations from examination bodies revealed that a high percentage of students fail mathematics examinations. The researchers have also observed that students complain that their performance in aptitude tests has always denied them the chance of been selected into academic programmes or job placement. Their reason being that the aptitude test they are subjected to do is always filled with difficult mathematics questions. One begins to wonder why basic mathematics knowledge does not help the students scale through such a test. Could the problem be that mathematics teachers give little or no attention to the relationship that exists between mathematics achievement and quantitative reasoning ability? This study, therefore, sought to find out the correlation between Mathematics achievement and quantitative reasoning ability in junior secondary school students.

1.2. Purpose of the Study

The purpose of this study was to investigate the correlation between student Mathematics achievement and quantitative reasoning ability.

Specifically, the objectives of the study were to:

1. Ascertain whether any relationship exists between student Mathematics achievement and their QR ability.
2. Determine if any relationship exists between the female students Mathematics achievement and their QR ability.
3. Find out the type of relationship that exists between the male students' Mathematics achievement and their QR ability.

1.3. Research Questions

The following research questions were answered.

1. What relationship exists between students' Mathematics achievement and their QR ability?
2. What is the relationship between the female students' Mathematics achievement their Mathematics achievement?
3. What is the relationship between the male students' Mathematics achievement and their quantitative reasoning ability?

1.4. Hypotheses

The following null hypotheses were tested at 0.05 alpha level.

$H0_1$: There is no significant relationship between students' Mathematics achievement and their quantitative reasoning ability.

$H0_2$: There is no significant relationship between the female students' Mathematics achievement and their quantitative reasoning ability.

$H0_3$: There is no significant relationship between the male students' Mathematics achievement and their quantitative reasoning ability.

1.5. Research Design

This study adopted a correlational research design. This design was adopted because it sought to establish a relationship between student's Mathematics achievement and their QR ability.

1.6. Population of the Study

The population of the study comprised of all the 1, 853 junior secondary school three (JSS3) students in the public co-educational junior secondary schools in Asari-Toru Local Government Area of Rivers State, Nigeria.

1.7. Sample and Sampling Technique

The sample for the study was 61 JSS3 students. The sample students were selected using a two-stage simple random sampling technique. The first stage employed a simple random sampling technique to select two schools and the second stage employed a further simple random sampling technique to select one arm of JS3 intact class from each sampled school.

1.8. Instrument for Data Collection

Two instruments were used to collect the data; the instruments were:

1. Mathematics Cognitive Achievement Test (MCAT).
2. Quantitative Reasoning Ability Test (QRAT).

MCAT consisted of 25 multiple choice items on the Mathematics concepts that were taught. Each multiple choice item was made up of options A to D. QRAT also consisted of equivalent 25 multiple choice items on QR with options A to D. Each set of options A to D in the two instruments was made up of three distracters and only one correct answer. Each correct answer in MCAT and QRAT was allotted 4 marks. This gave a total of 100 marks for each instrument.

1.9. Validation of the Instrument

The face and content validity of the MCAT and QRAT were carried out by two Mathematics educators. All necessary corrections were made to arrive at the final construction of the instruments that were actually used for the collection of data.

1.10. Reliability of the Instrument

The reliability of the instruments was established with the test-retest method. The researchers administered copies of the instrument to 22 students in two schools whose students were not participants in this study. After two weeks, these instruments were re-administered to the same retest students. The two sets of scores were correlated using Pearson Product Moment Correlation to obtain a reliability index of 0.81 for MCAT and 0.73 for QRAT.

1.11. Method of Data Collection

The intact class Mathematics teachers taught the students some Mathematics topics such as addition and subtraction of whole numbers, addition and subtraction of Roman numerals, multiplication and division of whole numbers. The same intact class Mathematics teachers taught the same students how to observe and identify the patterns of given quantitative reasoning samples, then apply their mathematical skills to obtain the other required QR problems with respect to the observed pattern. After the teaching, the students were administered the two instruments, MCAT and QRAT. The two sets (i.e. MCAT and QRAT) of the test were marked and collated. The collated scores were subjected to correlational analysis to ascertain if any relationship exists between students' Mathematics achievement and their QR ability.

1.12. Method of Data Analysis

The mean and standard deviation were used to answer the research questions while the Pearson Product Moment Correlation was used to analyse the data at 0.05 level of significance.

2. Results

Research Question 1: What relationship exists between students' Mathematics achievement and their QR ability?

$H0_1$: There is no significant relationship between students' Mathematics achievement and their quantitative reasoning ability.

Table 1 indicated that there was a positive moderate (0.64) relationship between students' Mathematics achievement and their quantitative reasoning ability. This result indicated that the higher the achievement of students in Mathematics, the higher their ability in QR. Increase in students' Mathematics achievement leads to a concomitant increase in their quantitative reasoning ability. The result in Table 1 further showed that there was a significant relationship ($P = 0.00$, $p<0.05$) between the Mathematics achievement of students and their QR ability. Therefore, the null hypothesis 1 was rejected.

Research Question 2: What is the relationship between the female students' Mathematics achievement their quantitative reasoning ability?

$H0_2$: There is no significant relationship between the female students' Mathematics achievement and their quantitative reasoning ability.

Table 2 indicated that there was a positive moderate relationship between female students' Mathematics achievement and their quantitative reasoning ability in junior secondary schools ($r= 0.75$). The result further showed that an increase in female student Mathematics achievement leads to increase in quantitative reasoning ability in junior secondary schools ($p= 0.00$, $p<.05$). Therefore, the null hypothesis 2 was rejected the alternative hypothesis was retained.

Table 1. Correlation between students' Mathematics achievement and quantitative reasoning ability

Variable	N	Mean	SD	r	p-value	Decision
Math Achievement	61	82.45	16.71			
QR Ability	61	87.30	14.30	0.64	0.00	S

S=Significant, p<.05; SD= Standard Deviation.

Table 2. Correlation between female students' Mathematics achievement and quantitative reasoning ability

Variable	N	Mean	SD	r	p-value	Decision
Math Achievement	35	85.90	14.41			
QR Ability	35	89.30	14.31	.75	.00	S

S=Significant, p<.05, SD= Standard Deviation.

Table 3. Correlation between male students' Mathematics achievement and quantitative reasoning ability

Variabl	N	Mean	SD	r	p-value	Decision
Math Achievement	20	79.00	18.44			
QR Ability	20	85.30	14.37	.55	.00	S

S=Significant, p<.05; SD= Standard Deviation.

Research Question 3: What is the relationship between the male students' Mathematics achievement and their quantitative reasoning ability?

$H0_3$: There is no significant relationship between the male students' Mathematics achievement and their quantitative reasoning ability.

Table 3 indicated that there was a positive fair relationship between the male students' Mathematics achievement and their quantitative reasoning ability in junior secondary schools (r= 0.55). The result further showed that increase in student Mathematics achievement leads to an increase in quantitative reasoning in junior secondary schools (p= 0.00, p<.05). Therefore, the null hypothesis 3 was rejected and the alternative hypothesis was retained.

3. Discussion of Findings

After carrying out the analysis RQ1 and HO_1, the findings revealed that there was a positive moderate relationship between students' quantitative reasoning ability and their Mathematics achievement in junior secondary schools. This positive moderate relationship between students' quantitative reasoning ability and Mathematics achievement means that as scores on Mathematics achievement increases, there is also a corresponding increase in students' quantitative reasoning ability and vice-versa. This means that most students, who achieved high in Mathematics also had a high quantitative reasoning ability which made them score high in QRAT. When subjected to Pearson product moment correlation analysis, an r-value of 0.64 was found to be statistically significant at 0.05 significant level. The result, therefore, was that there is a significant positive relationship between student Mathematics achievement and their quantitative reasoning ability in junior secondary schools. This finding is in agreement with the finding of Anyanwu (2012) where students who were exposed to Mathematics and quantitative reasoning lessons performed better in QRAT than those students who were only exposed to Mathematics. This finding is also in line with the assertion of that quantitative reasoning ability is not Mathematics. This is because students who were exposed to only Mathematics did not possess the quantitative reasoning ability to excel in QRAT. There is a moderate positive relationship between students Mathematics achievement and their quantitative reasoning ability. Students, therefore, need to be taught how to observe patterns from the sample and then apply basic mathematical processes to resolve quantitative reasoning test items.

Another important finding was in RQ2 and HO_2, where it was shown that there was a positive moderate relationship between the female student Mathematics achievement and their quantitative reasoning ability in junior secondary schools. This positive moderate relationship between Mathematics achievement and quantitative reasoning of female students means that as scores on Mathematics achievement increases there is also a concomitant increase in their quantitative reasoning ability and vice-versa. When Pearson product moment correlation coefficient analysis was applied, r-value of 0.75 was found to be statistically significant at 0.05 significant level Therefore, the result is that there is a significant positive relationship between female student Mathematics achievement and their quantitative reasoning ability in Junior Secondary Schools.

Finally, the findings from RQ3 and HO_3 indicated that there was a positive fair relationship between male students' Mathematics achievement and their quantitative reasoning ability in junior secondary schools. This positive fair relationship between Mathematics achievement and quantitative reasoning ability of the male students' means that as scores on Mathematics achievement increases, there is also a corresponding increase in quantitative reasoning ability, and vice-versa. Applying Pearson product moment correlation analysis, r-value of 0.55 was found to be statistically significant at 0.05 significant level. The result, therefore, is that there is a significant positive relationship between Mathematics achievement and quantitative reasoning ability of the male students in junior secondary schools.

The difference between the R-value of the male and female students could be attributed to certain reasons. Perhaps the girls are more patient at finding solutions to the cognitive task or numerical reasoning task and serious with their calculating courses in general than the boys. Furthermore, as it seems to be a male dominating course, the girls may have taken the baton of excellence to strive and excel like their opposite counterpart.

4. Conclusion

Based on the findings of the study, it was concluded that there is a significant positive relationship between students' achievement in Mathematics and their quantitative reasoning ability. This study also concluded that the mathematical knowledge and skills which students acquire in mathematics have a positive moderate relationship when students are exposed to how it can be employed to solve QR test items based on the given sample. This link is very crucial since resolving QR test items do not solely rely on how much mathematics a student can solve but rather the extent to which students can observe and identify the given sample patterns in addition to how much mathematics a student can solve.

5. Recommendations

The following recommendations were made based on the findings of this study.

1. Quantitative reasoning should be learnt in schools as a subject on its own to allow more time for grooming of its skills and processes.
2. Teachers should involve both male and female students in quantitative reasoning tasks and also establish the relationship between QR and Mathematics processes.
3. Textbook authors, curriculum planners and Mathematics teachers should embrace quantitative reasoning as a skill which sharpens the numerical reasoning faculty of students and prepares them for a better performance in aptitude tests.

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