



(RESEARCH ARTICLE)



Effect of problem solving method on the performance of mathematics students in public secondary schools in Rwanda: A case of Karongi district

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Abstract

The aim of this paper was to investigate the effect of problem solving method on the performance of Mathematics students in public day Schools in Rwanda” A case of Karongi District’. Simple random sampling technique was further applied to obtain Mathematics teachers and students of senior 4,5 and 6, making 783 target students. The study used a sample of 230 respondents from the sampled schools. The collected data was analyzed using descriptive statistics, correlation, and regression analysis through the statistical package for social science (SPSS) version 21. The data collected were analyzed using descriptive statistics and multiple regression. The results of the findings indicated that the teaching of mathematics via the problem solving method was more correlated with the performance of students in Karongi District ($r = 0.708$; $p = 0.000$). Multiple linear regression analysis showed that problem solving method contributed to 70.2% of variation on the performance, hence plays a vital role in performance of Mathematics students in public secondary schools in Karongi District. Additionally, it was further inferred that problem solving method increases positive attitudes toward learning Mathematics subject. The study recommended that the mathematics teachers should practice constructing questions to include problems that are relatively neither easy nor difficult, so that every student can practice, which will foster students’ creative.

Keywords: Problem solving method; Performance; Mathematics; Students

1. Introduction

Education cannot be made more effective without effective teaching. There are so many devices for effective teaching and an effective technique can ensure effective learning. It is being felt that there should be new techniques of teaching and learning (Iqbal, 2014). Developing counties, still use lecturing as a major teaching method which, however, needs blending with other methods and approaches. This has been suggested by Grobbelaar (2018) when he reported on the teaching of higher education in South Africa. Farooq (2010) points out that a “problem” usually indicates a challenge, the meeting of which requires study and investigation. Skinner (2004) states that the term “problem-solving” is defined as the frame work or pattern within which creative thinking and learning takes place. It is a process of overcoming difficulties that appear to interfere with the attainment of a goal.

Problem-solving is a high-level thinking skill that requires the ability to identify the nature of a problem, deconstruct it, and develop an effective set of actions to address the challenges related to it, which should be provided to students in the increasingly complex world Problem-solving is the cognitive process of finding a means to achieve goals (Mefoh et al., 2017). Problem-solving helps students develop skills to solve problems in the real world (, and it influences how they construct their thoughts and knowledge (Fitriani, 2020).

Problem-solving in mathematics is a fascinating activity for most students that can improve motivation which makes mathematics more interesting for many students. However, problem solving can also decrease motivation if speed,

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precision, format neatness, and finding the correct answer (Werras, 2018). Problem solving is difficult and it can be very frustrating for students if their teachers do not exhibit patience and understanding and offer unobtrusive assistance. In teacher's approach of problem solving by providing a relaxed supportive classroom environment, student can have the satisfaction of finding creative and original solutions to mathematics problems. Kolawole and Oluwatayo (2005) noted that effective teaching implies productive, purposeful, result oriented, qualitative, meaningful and realistic teaching. The essence of being an effective teacher views on what to do to foster student learning. Mathematics teachers should therefore adopt teaching methods that will enable the students to understand whatever concepts topic or principles being taught.

Problem-solving gives students the opportunity to work with their peers, interact socially, share new ideas think critically, and organize creative ideas in order to solve the problem. The students' problem-solving skills are not merely valued by their learning results but also by their understanding and learning activities for each of the problem-solving steps (Melawati et al., 2022). Problem-solving is the ability to understand issues as well as the steps involved (Mandina and Ochonogor, 2018). Understanding problem-solving is the basis for determining actions and the next problem-solving steps (Laurens, 2018). Understanding learning material and constructing students' own meaning are vital to statistical learning or the learning of any other discipline (Wang et al., 2022). The students' understanding will affect their learning achievement and enthusiasm. The students need to understand the problem well before making the right decision to solve it. They will use their prior knowledge to understand the problem (Simamora et al., 2017).

Mathematics is the most international of all subjects, as is mathematical understanding. The status of mathematics as a basic science or knowledge base supports the development of technology. There is no doubt that the role of mathematics is very important for the success of national establishment, and it is supported by the development of science and technology. High school students are expected to master mathematics. Mathematics is needed by students not only as a means of scientific thinking, but also to develop the ability to think logically. However, students think mathematics is hard. Problem-solving skills develop faster, if the solver gets newer and newer experience with the activity. Students' performance in problem-solving improves, if they repeatedly encounter the same type of problem or if they can make use of their previous experience (Fitriani, 2020).

Improvement of students' performance in problem solving requires much more than simply giving them many problems to solve. Problem solving is a very complex process that requires the teacher to be familiar with the model and the nature of problem solving. Teachers need to have a proper definition of a problem and three basic assumptions 'about problem solving before they can begin to teach problem solving is for everyone, growth in problem solving ability is the result of carefully planned instruction and problem solving develops slowly over a long period of time (Kantowski, 2010).

Various methods of teaching Mathematics are known, such include guided demonstration method, discussion method, problem-solving, expository individualistic methods. These methods depend on various forms of teacher –student-activities through some methods are more activity oriented than others. Problem-solving is a systematic approach that reviews learning competencies, comprehending and composing critical and creative thinking these features are most important dimensions of thinking and learning in regardless of the acknowledgement of the importance of developing problem-solving skills, relatively little research has been conducted on the theme in the field of instructional design (Jonalsen, 2014). It is against this background that this research sought to examine the effect of problem-solving methods of teaching on performance of Mathematics students in Karongi District.

This study sought to achieve the following research hypothesis:

H₀₁: There is no significance effect between problem-solving method and performance of Mathematics students in public secondary schools in Karongi District.

2. Methodology

This study evaluated the effect of problem solving method on student's performance in mathematics in public secondary schools of Karongi in Rwanda. For this study, the population was formed by public secondary school teachers from 6 public secondary schools offering general education in Karongi District of Rwanda. The study targeted those six schools because they are more affected with a big percentage of enrollment rate of students. Thus, the study targeted students, deans of studies, head teachers and teachers from those six selected schools. Besides, the research targeted secondary school Mathematics teachers since the study was to assess the effect of teaching methods on performance of Mathematics in public secondary schools in Karongi District. Science/Mathematics students of senior 4,5 and 6 was

targeted because they have better knowledge and experience about their schools' teaching and learning methods compared to other students in their respective schools

Table 1 Size of population of selected schools

Schools	Number of teachers	Number of Dean of studies	Number of head teacher	Number of Students	Total population
ES Bwishyura	4	1	1	138	144
GS Nyegabo	3	1	1	121	126
GS Kibuye	5	1	1	98	105
GS Nyamarebe	6	1	1	162	170
GS Nyabikenke	2	1	1	139	142
GS Rurangwe	2	1	1	125	129
Total	22	6	6	783	817

Source: Karongi district report, 2022

Stratified sampling, purposive sampling and simple random sampling were used in this study. Stratified sampling was used to select a sample of 6 schools from other public secondary schools. The aim was to ensure that all schools in the region were represented in the study. Schools were stratified or clustered and then one school was randomly selected. The headteacher of the sampled schools were purposively selected to participate in the study. A simple random sampling method was also used to select mathematics teachers and pupils in grades 4, 5 and 6, i.e. 783 pupils from the sample of schools.

In addition, the study used the following formula proposed by Yamane (1973) to determine the sample size, as it is too large to waste scarce resources and may expose more participants than necessary to risk.

$$n = \frac{N}{1 + (N)(e^2)}$$

Where:

n = sample size

N = the population size

e = the acceptable sampling error (5%) at 95% confidence level

Thus; $n = 817 / (1 + 817) (0.05)^2$

$n = 272.3 = 272$ respondents

A sample of 272 respondents was targeted to participate in this study. This formula was used to estimate a representative sample. A total number of 272 respondents was taken as sample size. The following is the table showing sample size for each category of five selected schools:

Table 2 Table representing a sample size

Schools	Number of teachers (Mathematics)	Number of Dean of studies	Number of head teacher	Number of Students	Sample size
ES Bwishyura	2	1	1	44	48
GS Nyegabo	1	1	1	40	43
GS Kibuye	2	1	1	30	34
GS Nyamarebe	3	1	1	53	58
GS Nyabikenke	1	1	1	44	47
GS Rurangwe	1	1	1	39	42
Total	10	6	6	250	272

Source: Researcher, 2023

In this study the researcher used interviews, questionnaires, and documentary review. Closed –ended questions were used where the answers were divided into categories such discrete, distinct and relatively few in number. It is easier for respondents to answer because they had only to choose categories. In that way a chance for irrelevant answers is limited to the minimum, because appropriate answer categories were provided. The main respondents were being teachers that was given the questionnaire as they were enough time to respond to the questions based on specific objectives. Questionnaires were given to Mathematics teachers, dean of studies and students from senior 4, 5 and 6.

The study involved oral questions based on the use of interview guides. This was a flexible way, because questions were both open and closed ended. This method helped the interviewer to collect supplementary information about the respondents as well as the researcher probed for more specific answers while at the same time helping the researcher to repeat a question when the response indicated that the respondent misunderstands the question

Interview guides were given to the head teachers. The respondents were requested to answer questions, and the researcher used semi-structure interview questions which enabled the researcher to ask broad questions in any order considered appropriate. Also, questions gave the respondents room to answer freely and amplify the responses. The respondents were interviewed at their perspective school.

3. Results

In this study the research sampled Mathematics teachers, headteachers, and science/Mathematics students of senior 4,5 and 6 because they have better knowledge and experience about their schools' teaching and learning practices compared to other students in their respective schools. Table 3 shows the return rate of respondents.

Table 3 Response rate

Respondents	Targeted	Obtained	Response rate(%)
Head teachers	6	6	100
Teachers of Mathematics	16	12	75
Students	250	212	84.4
Total	272	230	84.5

Source: Primary data, 2023

As shown in table 3, from the targeted respondents, four questionnaires from teachers and 38 questionnaires from students were not returned, so the participation rate was reduced to 12 (75%) of the teachers and 212 (84.4%) of the students. Regarding headteachers, the study sampled 6 school headteachers from 6 secondary schools and 6 of them interviewed; therefore, the response rate was 100%. Overall, the response rate of respondents was 84.5%.

3.1. Descriptive Statistics

Effect of problem solving method on the performance of mathematics students in public secondary schools in Karongi District.

In this research the study attempted to determine the effect of problem solving method on academic performance of mathematics subject in public day schools in Karongi District in Rwanda. The respondents were asked to rate the statements by indicating the extent to which they apply to their organization in 5-point Likert scale as shown on: 5. Strongly Agree (SA), 4 Agree(A), 3. Neutral (N), 2. Disagree (D) and 1. Strongly Disagree (SD). Besides, the mean and deviation were used for interpretation of the findings where mean (M) is the average of group of scores and it is sensitive to extreme score when the population samples are small. Moreover, the standard deviation (SD) was also used to measure the variability in those statistics as it shows how much variation is there from the average (mean).

Table 4 Problem solving method and performance of Mathematics students

Statements	Mean	Std Dev
This method encourages students to use intuitive solutions as well as knowledge and skills they already possess	4.5	0.71
Teachers do not act as the central provider, but only as a supporter while using problem solving method	4.2	0.68
Teaching must focus on understanding as much as possible so that the learners can explain methods and connections	4.2	0.75
This method challenges students to use the strategy that would highlight the depth of their understanding of the concept involved	3.9	0.96
This method allows students to show the connections they have made between the concepts they have learned	4.1	1.05
Students learn from seeing different ways to solve a problem, either by students presenting their solutions or by the teacher presenting alternative solutions	3.5	1.22

Source: Field research, 2023

As shown in Table 4, the results relate to the six statements assessing the effect of problem solving method on the performance of Mathematics students in public secondary schools in Karongi District. The results show that for the first statement, the majority of respondents strongly agreed that problem solving method encourages students to use intuitive solutions as well as knowledge and skills they already possess, with a mean value of 4.5, and a high positive correlation standard deviation of 0.71. The second statement asked respondents whether teachers do not act as the central provider, but only as a supporter while using problem solving method. The results showed that the majority of respondents strongly agreed with this statement ($M=4.2$, $SD=0.68$). For the third statement, teaching must focus on understanding as much as possible so that the learners can explain methods and connections, the majority of respondents agreed with this statement, with a mean of 4.2 and a very positive and high standard deviation correlation of 0.75. The fourth statement asked whether this method allows students to show the connections they have made between the concepts they have learned. Respondents strongly agreed with this statement, with an average mean of 4.1 and a very strong positive standard correlation of 1.05. The next item was whether this method challenges students to use the strategy that would highlight the depth of their understanding of the concept involved. The majority of them strongly agreed that statement with a mean of 3.9 and a very high positive standard deviation of 0.96. On the last statement respondents were asked if students learn from seeing different ways to solve a problem, either by students presenting their solutions or by the teacher presenting alternative solutions ($M=3.5$, $SD=1.22$). From the results, it implies that the majority of respondents strongly agreed and agreed that all of the above are key elements of problem solving method used in their six selected schools and have an effect on performance in Mathematics students in public secondary schools in Karongi District

3.2. Correlation analysis

The findings of the correlations between the independent variables and the dependent variables are summarized and presented in Table 5

Table 5 Correlation between problem solving and Performance of mathematics

		Problem solving method	Performance of Mathematics students
Problem solving method	Pearson Correlation	1	
	Sig. (2-tailed)		
	N	230	
Performance of Mathematics students	Pearson Correlation	0.708**	1
	Sig. (2-tailed)	0.000	
	N	230	230

** . Correlation is significant at the 0.01 level (2-tailed).

According to the findings reported in Table 5, the Pearson correlation analysis showed that problem solving method ($r=0.708$, $p=0.000$) is positively and significantly related to performance of Mathematics students in public secondary Schools in Karongi District. The correlation was deemed to be statistically significant since the p-value was less than 5%. The findings therefore showed that there is a positive and statistically significant relationship between problem solving problem method and performance of Mathematics students in the six sampled public day schools in Karongi District.

The model specification for student Performance in Mathematics establishes that problem solving method has a positive effect on Performance of Mathematics students in public secondary schools in Karongi District and the relationship is statistically significant ($p > 0.05$).

These findings are similar with Abdu-Raheem (2012) findings in his study on the effect of problem-solving method of teaching on secondary school students’ achievement and retention in Mathematics. He found that problem-solving method is more effective than conventional lecture method in improving students’ achievement in Mathematics.

3.3. Multiple Regression

The study used multiple regression to test the following hypothesis:

H₁ There is no significant effect between problem solving method and performance of Mathematics students in Secondary Schools in public day schools in Karongi District

Table 6 Model summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.838 ^a	0.702	0.691	0.82701

a. Predictors: (Constant), Problem solving method

The R-squared shows the variation in the dependent variable that can be explained by the independent variables being studied. The R-squared in this study was 0.702, which implies that the independent variable can explicate 70.2% of the dependent variable whereas the remaining 29.8% variation is explained by other factors which are not included in the model.

Table 7 Analysis of Variance (ANOVA)

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	182.035	4	45.509	66.538	0.000 ^b
	Residual	77.287	113	0.684		
	Total	259.322	117			
a. Dependent Variable: performance of Mathematics students						
b. Predictors: (Constant), problem solving method						

In an attempt to test the significant of the model, the study used ANOVA. From Table 7 the P-value is 0000^b which is less than 0.05 thus the model is statistically significance in predicting how problem solving method affects the performance of Mathematics students. The F critical at 5% level of significance is 66.538, and this shows that the overall model was significant. There exists significant relation between the dependent variable (performance of Mathematics students) and the independent variable (problem solving method).

4. Discussion

From the findings, the study found that problem solving method affects performance of Mathematics students, as this method encourages students to use intuitive solutions as well as knowledge and skills they already possess, it helps also teachers not to act as the central provider, but only as a supporter while using problem solving method and teaching is focused on understanding as much as possible so that the learners can explain methods and connections, when teaching focused on understanding as much as possible so that the learners can explain methods and connections. Besides,

findings revealed also that this method challenges students to use the strategy that would highlight the depth of their understanding of the concept involved, it allows students to show the connections they have made between the concepts they have learned and Students learn from seeing different ways to solve a problem, either by students presenting their solutions or by the teacher presenting alternative solutions

The interview data gathered the views of the participants on the effect of problem solving method on the performance of the students in Mathematics subject in Karongi District.

The head teachers and District Education Officer (DEO) of Karongi District have interviewed. The findings from the interview showed that all respondents unanimously agree that there is a strong correlation between problem solving method of learning and the performance of students in the Mathematics subject as expressed in the following report from the Headteacher A during the interview, he stated that:

“Problem-solving as an important life skill that covers various processes, such as analyzing, interpreting, predicting, evaluating, and reasoning. Problem-solving is a complex process that includes cognitive skills as well as affective and behavioural characteristics. Here most of the time the teacher wants to show them [the students] that usually there really is more than one solution and that they shouldn't worry if someone else in the class solved it differently. This doesn't necessarily mean that they are wrong. He wants to reinforce their confidence that it is possible to solve in more than one way “(20th November, 2023).

The DEO also observed that the teacher's expectations of the students are essential. Students only learn to handle complex problems by being exposed to them. “

He reported:

“Students need to have opportunities to work on complex tasks rather than a series of simple tasks devolved from a complex task. This is important for stimulating the students' mathematical reasoning and building durable mathematical knowledge.”

These findings are relevant with Eduard (2019) who stated that the problem solving approach emphasizes that important mathematics concepts and procedures can be best taught through problem solving tasks or activities which engage students in thinking about the important mathematical concepts and skills they need to learn

5. Conclusion

The research results have implications for and contribute to secondary school mathematics education. Understanding the problem-solving process can assist students in processing information and building knowledge about the social and physical worlds around them. When students understand the problem-solving process, they are able to: design a discovery; think and act creatively; solve the problem realistically they have faced; interpret and evaluate the observation results; stimulate the development of thinking progress to solve the problems appropriately they have faced; and make school education more relevant to life. This means that understanding the problem-solving process has an impact not only on good mathematics learning results but also on education in general. Therefore, based on the findings, the study concluded that that problem solving method affects performance of Mathematics students in those six selected schools in Karongi District as this method encourages students to use intuitive solutions as well as knowledge and skills they already possess.

Hypothesis testing results show that problem solving method have an effect on the results of students' mathematical learning. In solving problems relating to a matter, which is not routine, basic concepts and more mathematics learning experience, acquired through the process of teaching and learning in the classroom and obtained from the environmental community, are required. Therefore, the researcher can conclude by saying that the research hypothesis was tested; verified and then it is rejected referring to the statistical (regression analysis) findings and then according to the research, the correlation of 70.2% categorized as positive and very high correlation; this leads to confirm that there is significant relationship between problem solving method and performance of Mathematics students in public secondary schools in Karongi District.

Recommendations

It was recommended that the mathematics teachers need to integrate the problem-solving approach into all mathematics learning materials, implement it, and ensure the students' understanding of its process before asking them

to do the mathematics task to increase their mathematics learning results. To support the problem-solving approach or model in mathematics learning, mathematics teachers must consider the appropriate learning tools and media. Students who receive lower mathematics problem-solving understanding and learning results must collaborate in mathematics learning with those who receive higher results in order to increase their mathematics knowledge and cognitions. The local government, through the DEO, must develop and implement a primary school mathematics education curriculum based on a problem-solving learning model. Finally, the mathematics teachers should practice constructing questions to include problems that are relatively neither easy nor difficult, so that every student can practice, which will foster students' creative thinking

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

Statement of informed consent

Informed consent was obtained from all individual participants included in the study.

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