

Impacts of Problem-Based Learning on Performance and Retention in Mathematics among Junior Secondary School Students in Sabon-Gari Area of Kaduna State

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Abstract: This study was embarked upon to investigate the impacts of PBL on academic performance and retention in mathematics among junior secondary school students in Sabon-Gari local government area of Kaduna State, Nigeria. The research design adopted was pretest, posttest and post-posttest quasi-experimental non-equivalent control and experimental groups. Two instruments – mathematics performance tests 1 and 2 (MPT 1 & 2), developed by the researcher and validated were used for data collection with MPT 2 having Guttman split-half reliability coefficient of .83. Three research questions were raised and three hypotheses were formulated and tested at .05 level of significance. The research hypotheses were tested using independent sample t-test and related sample t-test through SPSS version 20.0. The findings revealed that there was significant mean difference between the performance of students exposed to PBL (ME = 10.51, SE = 1.22) and those exposed to traditional method (ME = 7.87, SE = .31), $t(112) = 1.97$, $p < .05$, no significant difference between male (ME = 11.74, SE = 1.92) and female (ME = 8.48, SE = .47), $t(59) = 1.30$, $p > .05$ students exposed to PBL and adequate retention among the students exposed to PBL as related sample t-test also revealed no significant difference (ME = 1.67, SE = 1.26), $t(60) = 1.31$, $p > .05$ between their posttest and post-posttest scores. It was therefore recommended that PBL should be encouraged by the Ministry of Education to be adopted by secondary school teachers in the classrooms.

Key Words: Problem-based learning; performance; retention; traditional method; gender.

Introduction:

The usefulness of mathematics cannot be undermined in the development and technological advancement of any society. The enormous applications of mathematics in physical sciences, biological sciences, engineering, social sciences, medicine and pharmacy are enough testimonies to its credits. The issue of whether or not mathematics is language free has raised some divergent opinions among mathematics educators worldwide (Mosqueda & Maldonado, 2013; Yushau & Omar, 2015). Despite these, mathematics still remains an important tool in actualizing societal development in countries with heterogeneous languages. However, it has almost become a norm in Nigeria and yearly occurrence of reporting poor academic performance in mathematics not only at primary and secondary levels but also at our tertiary institutions (Zakariya, 2016). Several attempts abound in the literature to identifying the causes of this nationwide poor mathematics performance among secondary school students. Prominent among these studies was the report of Ogundele, Olanipekun, and Aina (2014) who identified and discussed causes of poor performance in West Africa School Certificate Examination (WASCE) under five subheadings. In their study, teachers' factors and pedagogical content knowledge were identified as the first two major factors responsible for poor performance in the examination. Zakariya and Bamidele (2015) also investigated the causes of poor academic performance in mathematics among undergraduate students and found that poor quality of teachers' methodology of teaching was a significant factor. Invariably, teachers' adherence to traditional method of teaching in the classroom has been argued against over the years and alternative student-centred methods have been proposed as replacers.

Traditional teaching method was described as an activity where students passively absorbed pre-processed information and then regurgitate it in response to periodic multiple-choice or essay examinations (McCarthy & Anderson, 2000). It is a typical method and the most popular among secondary school teachers in this country. Traditional method had been criticized from its two major pedagogical limitations and shortcomings: lecture-based instruction and teacher-centred instruction (Dochy, Segers, Bossche, & Gijbels, 2003; Zakaria & Iksan, 2007). It has been characterized as lecture-based instruction because it emphasizes passive acquisition of

knowledge in such a way that students become passive recipients of knowledge which promote rote learning. The classroom activities involve the teachers either dictating the note, writing on the chalkboards or posing questions and answers that only demand basic recall of knowledge from the students while the students sparingly ask questions or exchange ideas among each other. Learning in such classrooms is therefore not for conceptual understanding but rather memorizing and recalling facts based on cognitive level of development. Moreover, traditional method has been characterized as teacher-centred instruction since it involves over 80% of the classroom activities dominated by the teachers. In such classrooms, the students solely rely on their teachers to make decision on what, when and how to learn. Zakaria and Iksan (2007) submitted that this method worked very well but it is unclear whether or not students are learning at higher conceptual thinking. These flaws and many others have made mathematics educators to devise many other student-centred approaches to teaching and learning among which is problem-based learning (PBL).

Problem-based learning (PBL) is a student-centered approach in which students, in a collaborative environment, generate various solutions to what are often perceived as real-life problems by using their existing knowledge and new information acquired through surveying different resources (Tarhan & Ayyıldız, 2015). The first utilization of this approach was at the Medical School of Case W. University, USA in the 1950s and began as the sole method of teaching in medicine at McMasters University, Canada in the late 1960s (Akinoglu & Tandogan, 2006; Klunklin, Subpaibongid, & Keitlertnapha, 2011). PBL has gained wide acceptance not only in the medical schools but also in the teaching of science, mathematics and engineering (Hung, Jonassen, & Liu, 2007). The primary goals of PBL are to make the students act as professionals in the construction of knowledge, encourage effective cooperative skills, enhance the development of students' higher-order thinking, foster their social skills and boost their acquisitions of necessary skills to be life-long learners, (Azer, 2009; Edwards & Hammer, 2006; Sungur, Tekkaya, & Geban, 2006; Tarhan & Ayyıldız, 2015). According to Barrows (1996) in Dochy et al. (2003) PBL classrooms have the following characteristics: learning is student-centered, learning occurs in small student groups, a tutor is present as a facilitator or a guide, authentic problems are primarily encountered in the learning sequence, the problems encountered are used as tools to achieve the required knowledge and new information needs to be acquired through self-directed learning. More than ten advantages of PBL over traditional method and few limitations were highlighted by (Akinoglu & Tandogan, 2006) among which are: PBL develops self-control in students, it develops their problem-solving skills and develops students' high level and scientific thinking. The numerous advantages of PBL and its robust adaptability have contributed to its correlations with students' achievements, performance, retention and attitudes by educators worldwide.

Numerous reports are available in the literature providing evidences for the overall effectiveness of PBL in the classrooms (Bilgin, Erdal, & Sozbilir, 2009; Cheriani, Tahmir, Manda, & Dirawan, 2015; Kolodner et al., 2003; Mcparland, Noble, & Livingston, 2004; Saalu, Abraham, & Aina, 2010; Sindelar, 2010). Alajmi (2014) in her doctoral thesis investigated the factors that influence students' performance in PBL classrooms and found that students' demographic factors such as age and sex and backgrounds had no effect on the acceptance of PBL as a learning experience among the students. Moreover, she found that age influenced the performance of students in a PBL classroom with younger students (16-20 years) performing better than the older ones while no significant relationship was found between students' verbal interaction and their achievements. Some interesting software, games and effective online learning environments based on PBL approach have also been developed and evaluated in the literature (Chang, Chen, & Chen, 2015; Dorneles, André, & Rigo, 2015; Gündüz, Alemdağ, Yaşar, & Erdem, 2016). Moreover, Xiuping (2002) in his study combined PBL with the traditional method of teaching and found that PBL is a wonderful way of teaching but traditional method had an edge when the material to learn is huge and the time allotted is limited.

Haji Boty and Shahrill (2015) narrated a teacher's experience of using PBL in mathematics lessons. Their study involved a class of year 9 students and a teacher in one of their secondary schools in Brunei. In-class notes, video-recorded observations, field notes and teacher's interviews were utilized in data collection and their results revealed that questioning techniques and PBL fact lists were effective tools in monitoring and guiding the students to construct solutions to particular problem in PBL classrooms. In Nigeria, Fatade, Mogari and

Arigbabu (2013) reported an empirical study on the effects of PBL on students' achievements in further mathematics. The research designed was quasi-experimental involving 42 students taught with PBL and 54 students taught using traditional method. Their findings revealed a significant difference between the mean achievement of students taught using PBL (ME= 43.79) and the mean achievement of students taught using traditional method (ME=34.96). Despite the effectiveness of this approach as reported in the literature few or no study had been reported on its application to teaching and learning of mathematics among junior secondary school students in Nigeria. Therefore, this study was aimed at determining the effects of problem-based learning on academic performance and retention in mathematics among junior secondary school II (JSS II) students.

Objectives of the Study:

The objectives of this study were to:

1. determine the impacts of PBL on performance in mathematics among JSS II students in Sabon-Gari LGA
2. determine the impacts of PBL on retention of mathematics concepts among JSS II students in Sabon-Gari LGA
3. Examine the gender effects of PBL among JSS II students in Sabon-Gari LGA.

Methodology:

The research design adopted for this was quasi-experimental involving pretest, posttest, post-posttest, non-equivalent control and experimental groups. A sample of 149 students were randomly selected from a population of 664 JSS II students within Sabon-Gari local government area of Kaduna State. The sample consisted of 68 students (39 males and 29 females) in the control group (CG) and 81 students (53 males and 28 females) in the experimental group (EG). Two instruments were developed: (i) Mathematics Performance Test 1 (MPT 1) for pretest and (ii) Mathematics Performance Test 2 for posttest and post-posttest (MPT 2). The two instruments were in multiple-choice format with options a – d and MPT 1 contained 10 items while MPT 2 contained 20 items. Only MPT 2 was validated and its reliability coefficient using Guttman split-half was computed to be .83. The students in both CG and EG were given MPT 1 to test the equity of their ability levels followed by a treatment period of 4 weeks with CG students taught using traditional method and EG students taught using PBL. At the end of the treatment period MPT 2 was administered to the students in the two groups and a reshuffle of MPT 2 was administered again after two week to the EG students only for retention. Three research questions were raised and the following null hypotheses were formulated and tested at .05 level of significance.

H_{O1} There is no significant difference between the mean performance of JSS II students taught using PBL and those taught using traditional method.

H_{O2} There is no significant difference between the mean retention of JSS II students taught using PBL.

H_{O3} There is no significant difference between the mean scores of male and female JSS II students taught using PBL strategy.

The data were analyzed using SPSS version 20.0 and the hypotheses were tested using t-test independent and t-test dependent for retention.

Results and Discussion:

Table 1 presents the data and the independent sample t-test analysis of pretest test scores of students in CG and EG.

Table 1: Independent sample t-test between pretest scores of CG and EG

| Group | N | Mean | SD | MD | df | t-value | p-value |
|--------------|----|------|------|-----|-----|---------|---------|
| Control | 68 | 4.28 | 1.64 | .43 | 147 | 1.74 | .09* |
| Experimental | 81 | 3.85 | 1.37 | | | | |

*not significant, $p > 0.05$

Table 1 revealed that the mean score of CG students was 4.28 and that of EG students was 3.85 and standard deviations of 1.64 and 1.37 respectively. A mean difference of .43 which is not statistically significant $t(147) = 1.74, p > .05$. Therefore, we can conclude that the students in both CG and EG were averagely equal in their ability levels before treatment administration. This result gave us a solid premise (95%) to ascribe any observed significant difference in the two groups to the treatments applied to them.

In order to test the null hypothesis 1, Table 2 presents the data and the independent t-test analysis of posttest scores of students in CG and EG. The discrepancy in the numbers of students in Table 1 and Table 2 was due to absentism and lateness of some students.

Table 2: Independent sample t-test between the posttest scores of CG and EG

| Groups | N | Mean | SD | df | t-value | p-value |
|--------------|----|-------|------|-----|---------|---------|
| Control | 53 | 7.87 | 2.25 | 112 | 1.97 | .05* |
| Experimental | 61 | 10.51 | 9.51 | | | |

*significant at $p \leq 0.05$

It can be read from Table 2 that the mean scores of CG students was 7.87 and that of the EG students was 10.51 with standard deviations of 2.25 and 9.51 respectively. A mean difference of 2.64 was recorded which is statistically significant $t(112) = 1.97, p \leq .05$. The null hypothesis 1 was therefore rejected. Hence, there is significant difference between the mean performance of JSS II students taught using PBL and those taught using traditional method. Invariably, research question 1 – is there any significant difference between the mean performance of JSS II students taught using PBL and those taught using traditional method? Has been answered. This finding was in accordance with results of Akinoglu and Tandogan (2006) who found that PBL had positive effects on academic achievements of students. The study of Fatade et al. (2013) which concluded that PBL enhanced academic achievement of students in further mathematics also corroborated this finding.

In order to test the null hypothesis 2, Table 3 presents the data and the related sample t-test analysis of post-posttest scores of students taught using PBL. The discrepancy in the numbers of students in Table 1 and Table 3 was due to absentism and lateness of some students.

Table 3: Related sample t-test between post-test and Post post-test scores of EG

| Score | N | Mean | SD | t-value | df | p-value |
|----------------|----|-------|------|---------|----|---------|
| Post-test | 61 | 10.51 | 9.51 | 1.31 | 60 | .20* |
| Post post-test | 61 | 8.85 | 2.65 | | | |

*not significant as $p > .05$

It can be read from Table 3 that the mean scores of EG students was 10.51 in the posttest and 8.85 in the post-posttest with standard deviations of 9.51 and 2.65 respectively. A mean difference of 1.66 was recorded which is not statistically significant $t(60) = 1.31, p > .05$. The null hypothesis 2 was therefore retained. Hence, there is no significant difference between the mean retention of JSS II students taught using PBL. We can therefore argue that students taught using PBL were able to retain contents taught over a period of at least two weeks. Invariably, the research question 2 – is there any significant difference between the mean retention of JSS II students taught using PBL? Has been answered. This finding was in accordance with results of Dochy et al. (2003) who found that PBL had positive effects on retention of students over a long period of time.

In order to test the null hypothesis 3, Table 4 presents the data and the independent sample t-test analysis of posttest scores of students taught using PBL. The discrepancy in the numbers of students in Table 1 and Table 4 was due to absentism and lateness of some students.

Table 4: Independent sample t-test between males and females of the EG

| Gender | N | Mean | SD | t-value | df | p-value |
|--------|----|-------|-------|---------|----|---------|
| Male | 39 | 11.15 | 11.72 | 0.7 | 59 | .49* |
| Female | 22 | 9.36 | 2.79 | | | |

*not significant as $p > .05$

It can be read from Table 4 that the mean scores of EG male students was 11.15 and that of the female students was 9.36 in the posttest with standard deviations of 11.72 and 2.79 respectively. A mean difference of 1.79 was recorded which is not statistically significant $t(59) = 0.7, p > .05$. The null hypothesis 3 was therefore retained. Hence, there is no significant difference between the mean scores of male and female JSS II students taught using PBL strategy. We can therefore argue that PBL works equally well for both male and female students without gender discrimination. Invariably, research question 3 – is there any significant difference between the mean performance of male and female JSS II students when taught using PBL strategy? Has been answered. This finding was in accordance with results of (Alajmi, 2014) who also found that PBL is gender insensitive.

Conclusion and Recommendations:

In this study, we investigated the impacts of PBL on academic performance and retention of JSS II students and found that PBL significantly enhanced the performance of students better than the traditional method. More so, students taught with PBL were able to retain the contents taught for at least a period of two weeks. Finally, we found that PBL was gender insensitive and therefore the method is applicable to both male and female students. We advocate that the findings of this study can be generalized or replicated in other parts of country for smooth integration into the national curriculum. Based on the findings of this study the following were recommended:

1. PBL should be encouraged by the Ministry of Education to be adopted by secondary school teachers in the classrooms.
2. Seminars and workshops should be organized by the national union of teachers to train secondary school teachers on the use of PBL in the classrooms.
3. Curriculum planners should encourage the integration of PBL into the secondary curriculum.

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