THE IMPACT OF THE USE OF THE PROBLEM-SOLVING APPROACH IN LINKING CLASSROOM MATHEMATICS TO REAL-LIFE ACTIVITIES ON LEARNERS' PERFORMANCE

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Abstract

The study aimed to determine the impact of using the Problem-solving approach to link classroom mathematics to daily life activities on learners' performance. The constructivist theory and Polya's problem-solving approach were employed to create a link between classroom mathematics and real-life mathematical perspective. A sample of two intact classes comprising 101 students was used for the study. The control class received the traditional instruction, while the experimental class was treated with the designed intervention. The results indicated a statistically significant improvement in the post-test of the Experimental Group. It is recommended that teachers should endeavour to use the problem-solving approach in teaching to enhance learners' performance.

Keywords: Polya's Problem Solving Approach, Traditional instruction, Control class Experimental group, contextualized problems.

Introduction

Teaching mathematics ought to link classroom mathematics to daily activities (Arthur et al., 2017; Nabie et al., 2013). This is to help bridge the gap between classroom mathematics and real-life activities. The importance of mathematics in developing our nation and the world cannot be stretched enough (Richardson et al., 2020). Since mathematics is the backbone of every country and also permeates every aspect of our lives, it is necessary to train secondary school learners to be able to think and reason mathematically (Richardson et al., 2020). Mathematics is compulsory in Ghanaian schools from primary to senior high school (SHS). It is also a requirement for admission into higher Institutions in Ghana due to its usefulness in the career development of the young ones (MOE, 2010).

According to a report by (Richardson et al., 2020; Xie, 2021), many research works are being carried out worldwide to help improve the teaching and learning of mathematics in various countries in this digital era. Regular assessments and rankings of mathematics achievements of various international countries by institutions such as Trends in Mathematics and Science Study (TIMMS) and Organization for Economic Cooperation and Development (OECD) have made mathematics teaching and learning very attractive, competitive, and adventurous. As the world is moving faster in terms of technological advancement, there is a need to find a pedagogical approach to teaching that could make learners innovative, creative, critical thinkers, and problem solvers (Apple, 2011). The poor problem-solving skills exhibited by Ghanaian learners in local and international assessments, according to Anamuah-Mensah & Mereku (2005), have been a source of worry for the stakeholders of education in Ghana (Abreh et al., 2018). Hence, there is a need to study this nature to find a lasting solution to the canker. The content students need to learn at the secondary school level in Ghana is spelled out in the Core Mathematics syllabus (MOE,,2010). Mullis & Martin (2019) put the mathematics curriculum in three perspectives; the intended, attained, and implemented. School Mathematical Activities are the daily life activities that require the application of the knowledge of mathematics. (Boaler et al., 2016) posited that mathematical understanding helps individuals develop oral communication and mathematical thinking skills. More so, the knowledge of mathematics is used in real-life modeling phenomena, predicting disaster, philosophy, medicine, digital encryption, and communication, among others (Amir et al., 2021).

However, examination results available at national and international examination Bodies like the West Africa Examination Council (WAEC) and Trends in Mathematics and Science Study (TIMSS) show that Ghana's performance in mathematics needs attention. Ghana's performance in mathematics has not been encouraging. A report released by the Organization for Economic Cooperation and Development (OECD), Education at Glance (EAG), ranked Ghana last but one in mathematics, science, and English test (Zou, 2019). Locally the statistics of the West Africa Senior High School Certificate Examination (WASSCE) results in Core Mathematics available at the West African Examination Council (WAEC) from 2012 to 2018 show that less than half of the candidates can obtain grades A1- C6 in the WASSCE (Abreh et al., 2018). According to the report, this worries parents and the government (MOE, ESA report 2018).

It has been observed that the difficulty that learners face in learning mathematics at the Senior High Schools in the Bekwai Municipal is not different from the national challenge. WASSCE results and the school-Based Assessment (SBA) accessed from the Bekwai Municipal Senior High Schools for the past five years show that learners are not doing well in mathematics as expected. The condition has partly been attributed to learners' lack of interest in the subject due to the traditional method of teaching mathematics in school instead of the Problem Solving Approach (Nabie et al., 2013). Amponsah-Tawiah, (2020) describes problem-solving as a complex mental process involving visualization, abstraction, and association. George Polya (1887-1985) defined it as a process of finding a solution to a problem to achieve a goal that seems complicated (Polya, as cited in (Arfiana & Wijaya, 2018). Even though there is no clear-cut definition, Problem-solving can be described as a process of finding a mathematical formulation that can be used to predict real-life phenomena.

Secondary education is free and accessible to every Ghanaian child (Asante & Agbee, 2021; Matey, 2020). Consequently, the solid mathematical competencies developed at the SHS level are requirements for those continuing into tertiary education and beyond and those who will exit formal education to venture into other professions and vocations. Mathematics as a core subject at this level has a profound implication for occupying such a spot. There is, therefore, the need to try teaching approaches that allow learners to explore their environment and find solutions to real-life problems.

This current study is based on the Constructivism theory in achieving its objectives. Constructivism learning theory, as posited by (Knapp, 2019), is a synthesis of multiple learning theories diffused in one form. Constructivism is about the ability of teachers to identify their learners' learning capabilities to provide the necessary conditions and materials to help the learners put their knowledge to practice(Adom et al., 2016). In a constructivist classroom, the learners construct their knowledge and understanding based on the conditions provided by the facilitator (Atta & Brantuo, 2021). Therefore, it promotes learners' motivation and critical thinking and encourages them to learn independently (Kusuma et al., 2021).

Polya's Problem-Solving Approach

The constructivist approach to learning and Polya's Problem Solving Approach are the leading theories for this research. (Tambunan, 2019), describe problem-solving as a complex mental process involving visualization, abstraction, and association. George Polya (1887-1985), a Hungarian mathematician, defined it as a process of finding a solution to a problem to achieve a goal that seems complicated Polya, as cited in (Arfiana & Wijaya, 2018). Even though there is no clear-cut definition, Problem-solving can be described as a process of finding a mathematical formulation that can be used to predict real-life phenomena. One of the primary reasons people have trouble solving mathematical problems is that no single procedure always works (Gunasegar & Maat, 2022). Every problem is slightly different. Furthermore, problem-solving requires practical knowledge of the specific situation. It is expected that students will apply and integrate a lot of mathematical skills and make decisions.

Linking learners' background experience to the classroom turns mathematics lessons into creative art, which has the power to develop mathematical thinking skills among learners. It has been grounded in research that learners' cultural background directly impacts their understanding of mathematical concepts. For instance, (Baba et al., 2018) posited that cultural factors play an essential role in Japanese mathematics Education. (Butakor, 2021) Also, in Ghana, the home environment has a role in teaching and learning mathematics. Their work (Cai & Wang, 2010) reveals that cultural factors must be considered in teaching and learning mathematics. In China, as posited by (Cai & Wang, 2010; Fuchs et al., 2020), most of the examples used in mathematics classrooms are based on learners' daily life activities. This encourages learners in different ways to approach calculations skilfully. Studies have demonstrated that countries that use local languages to teach mathematics usually perform better than those countries that use a second language to teach mathematics (Martin et al., 2020; Zou, 2019). This implies that culture plays a significant role in mathematics problem-solving. Therefore, the mathematics teacher must always bring the real world into the classroom (Putri et al., 2021; Surya et al., 2020). As observed by (Baah-Duodu et al., 2020), mathematics is best taught using hands-on and mind-on activities that learners see as fun and adopt as culture. Finding solutions to contextualized problems is termed mathematics problem solving (Polya, 1945) cited in (Amponsah-Tawiah, 2020). Mathematics Problem-solving approaches are in line with modern pedagogies like critical pedagogy and mathematics for social justice (Stinson et al., 2012), and mathematics for social justice (Stinson et al., 2012). Pedagogy of the oppressed (Freire, 2020; Giroux, 2010) and Realistic mathematics education (Amir et al., 2021; Barnes, 2005). Real-life situations differ in many forms, and the approach to finding solutions to contextual problems also differs. However, laid down processes are followed in solving mathematical problems in context. For instance, poly developed these four stages Understanding the problem, designing a plan, carrying the plan, and looking back (Polya, 1945). For this research, the following stages problem-solving approach has been adapted;

1. **Understanding the problem**

For any mathematical problem to be solved using this approach, the first step is to
Understand clearly the fundamental questions of the problem.
Translate the statement into mathematical symbols. Develop the model.

2. **Devise a plan to solve the problem** (Translate)
3. **Carry out the plan** (Solve the problem)

Substitution of the values into the model
Carry out the computational algorithms to get the solution.

4. **Authenticate the solution** (Look back)

Carefully examine the results to make sure it makes sense.
Relate the solution to the real-world context

Objective of the study

The study's objective was to investigate the impact of using the problem-solving approach as an instructional strategy to link classroom mathematics to real-life activitie.

Hypothesis

The following hypotheses were formulated based on the objective of guiding the study.

H_1: there is no statistically significant difference between the mean scores of the pre-test and the post-test of the experimental class.

H_2: there is no statistically significant difference between the mean scores of the control class and experimental classes' mean scores in the post-test.

Methodology

Research Design

A quasi-experimental design was used for the study. The target population was all Four Senior High Schools in the Bekwai Municipality in the Ashanti Region of Ghana. The researchers purposefully settled on two senior High schools for the study. The selection of the schools was based on the fact that both schools have not been performing well in the WASSCE, and there was a need for urgent measures to improve their performance. One class was selected from each school to participate in the study. Both classes were Form Two classes offering General Arts Program. The total number of students selected for the study was one Hundred and One (101) from both schools. The two intact classes were 51 students from school A and 50 from school B. The two classes were homogeneous in terms of their performance and terms of their weakness in mathematics. The rationale for selecting the second-year class for the study was that they have been in school for two semesters and are familiar with the SHS system. Again, they have two more years to write their final examination, WASSCE, so there is not much pressure on them to finish their syllabus. It is also anticipated that they might have recovered and gotten back on track if they encountered any form of poor tutoring at the Basic School. Since they have spent one full year in school, they are also mature enough to be used for the study so that the outcome can be trusted.

An initial test consisting of five Contextualised problems on Variation was given to them to assess their understanding of the basics of Variation as a topic. The test was marked and analyzed before the start of the intention. The two classes were grouped into control and experimental classes.

The intervention was designed for five weeks, and the timetable in both schools was Variation. The control class received regular instruction, but the experimental class received the intervention. Even though the two classes were homogeneous in terms of performance in mathematics, the Preintervention test showed the control class a little ahead of the experimental class. The researchers decided to administer the treatment (intervention) to the weaker class so that any improvement in performance on their side could be attributed to the intervention. Campbell and Stanley (cited in (Eduafo, 2014) indicate that pre-test and post-test comparisons provide a robust assessment of a pedagogical intervention by detecting possible challenges before or after treatment. Participants were not randomly assigned for convenience, as indicated by (Etikan et al., 2016; Taherdoost, 2016).

Research Instruments

The main instruments used for collecting data in this study were; pre-test and post-tests; these tools helped the researcher ascertain the level of the learners' skill and knowledge of the Mathematical concepts. The tests generally adopted criterion-reference tests involving questions on word problems involving direct and indirect Variation for the pre-test and the post-test.

Data Collection Procedure

A pre-test was conducted to verify the reality or otherwise of the problem that the researcher identified. It also helped to find out learners' basic knowledge in solving contextual problems and also as a means of assigning the classes into groups. A post-intervention test was administered immediately after the treatment to verify the effect of the intervention on the learners and answer the research question. The pre-intervention test contains five practical questions related to real-life activities that learners were to answer in sixty minutes. The questions were mainly on direct and indirect proportions based on ratios and proportions. The motive was to find out how ready learners were to learn Variation as the topic for the intervention. That is to test learners' relevant previous knowledge of Variation. Finally, the post-intervention test was also five in number, and learners were expected to answer all in sixty minutes. These questions were on Variation and were carefully selected concerning our daily life activities. The first two questions were on direct Variation, and the third one was on indirect Variation. The fourth question was on joint Variation, and the last one was on partial Variation.

Pre-Intervention

A pre-test was conducted to determine learners' difficulty in solving mathematical problems, especially contextual problems. The pre-test was also meant to determine how skilful or otherwise learners can tackle mathematical problems in context and how much understanding they have of the language (semantics). This enabled the researcher to assign the two classes into groups (control and experimental) and carefully deliver the planned intervention to administer a solution to the problem. In both classes, five weeks were used for the intervention and the post-intervention test.

Results

The results obtained from the pre-intervention and post-intervention tests were analyzed using the graphs, paired sample t-test, and independent t-test. The analysis was tailored to test the two-research hypothesis for the study as outlined below;

H0: there is no statistically significant difference between the mean scores of the pre-test and the post-test of the experimental class.

H_1: there is a statistically significant difference between the mean scores of the pre-test and the post-test of the experimental class.

Table 1 is the frequency table for the result of both pre-test and post-test for the experimental class. This shows the performances put up by the experimental group both before and after the designed intervention.

Table 1: Frequency Distribution for Experimental Class

	Pre-test	**Post-test**
Marks	**Frequency**	**Frequency**
11 – 20	5	0
21 – 30	8	3
31 – 40	12	6
41 – 50	13	7
51 – 60	12	10
61 – 70	0	11
71 – 80	0	10
81 – 90	0	3
TOTAL	**50**	**50**

Table 1: shows that 38 out of the 50 learners (representing 76.0%) scored 50% and below in the pre-test. The remaining 12 (forming 24.0%) scored 51% to 60%. Conversely, the post-test paints an exciting picture with a hooping 34 learners scoring above the 50% mark. It is worth of mention that the minimum mark was 30, and 16 learners had scores between this mark and 50%.

A close observation of Table 4.3 gives a visual impression of the performances of the experimental group in both tests. It is a true manifestation that the experimental class performed better in the post-test than in the pre-test. Therefore, this performance improvement can only be attributed to the planned intervention, which worked well as expected. To find out whether the differences in performance were statistically significant, the paired sample t-test was conducted.

To satisfy the assumptions for the t-test, the normality test was conducted. Table 2 gives the normality test results for the difference between the experimental group's pre and post-test scores.

Table 2: Tests of Normality for Experimental Group

	Kolmogorov-Smirnov[a]			**Shapiro-Wilk**		
	Statistic	Df	Sig.	Statistic	df	Sig.
Pre-test-post-test	.087	50	.200*	.976	50	.389

*. This is a lower bound of the true significance.
a. Lilliefors Significance Correction

From Table 2, using the Shapiro-Wilk figures, a P-value of 0.389 indicates that the data is normally distributed. Since 0.389 > 0.05, the data set does not significantly deviate from normal, hence we can go ahead and use the t-test to test the hypothesis.

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It was hypothesized that:

H_o: No statistically significant difference exists between the experimental group's pre-test and post-test mean scores.

H_a: There is a statistically significant difference between the experimental group's pre-test and post-test mean scores.

Table 3: Paired Samples Statistics of the Experimental Group

		M	N	SD	Std. Error Mean
Pair 1	Pre-test	40.34	50	12.237	1.731
	Post-test	58.98	50	15.990	2.261

Table 3: shows that the Experimental group had a higher mean score on the post-test than on the pre-test.

Table 4: Paired Samples Test for the Experimental Class

	M	SD	Std. Error Mean	t	df	Sig. (2-tailed)
PRE-TEST – POST-TEST	-18.640	8.502	1.202	-15.504	49	.000

From Table 4, the p-value of 0.000 is less than the alpha value of 0.05 (0.00 < 0.05). This warrants the rejection of the null hypothesis in favor of the alternate hypothesis. There is enough evidence to conclude a statistically significant difference between the experimental group's pre-test and post-test mean scores. This difference favors the post-test, and the only reason that can be attributed to this is the intervention the experimental class was taken through. For a balance and formidable analysis, the performance of the experimental group in the post-test was juxtaposed with that of the control group in the post-test. The second hypothesis was also tested using the paired sample t-test.

It was also hypothesized that:

H_o: There is no statistically significant difference between the mean scores of the control and the experimental groups in the post-test.

H_a: There is a statistically significant difference between the mean scores of the control and the experimental groups in the post-test.

Table 5: Group Statistics for the independent sampled t-test

Group	N	Mean	Std. Deviation	Std. Error Mean
Control	51	51.43	14.405	2.017
Experimental	50	58.98	15.990	2.261

It is clear from Table 5 that the Experimental group had a higher mean score in the post-test than the control group.

Table 6: Independent samples test of the post-test for both control and experimental groups

	F	Sig.	t	df	Sig(2-tailed)	Mean difference	Standard error difference

Equal variances assumed	1.172	.282	-2.494	99	.014	-7.549	3.027
Equal variances not assumed			-2.491		.014	-7.549	3.030

*95% confidence interval of the difference

Table 6: gives statistically significant results on Levine's test, which suggests Equality of variances for the two groups. The independent t-test for equal variances assumes a P-value of 0.014 < 0.0 5, indicating insufficient evidence to support the null hypothesis. There is, therefore, the justification to reject the null hypothesis and conclude that there is a statistically significant difference in the mean scores of the experimental group and the control group in favor of the experimental group.

Discussions

Regarding the analysis, the experimental class's test results after the intervention showed significant improvement. The two Null hypotheses were rejected since the intervention made a difference in the performance of the class that received the intervention. It affirms the earlier studies that observed that linking mathematics lessons to actual life activities enhances learners' conceptual understanding, procedural fluency, and computational algorithms. (Arthur et al., 2017; Baah-Duodu et al., 2020; Huinker, 2018; Nabie et al., 2013).

Conclusion

Practically the improved performance did not occur accidentally but because of the planned three-stage, problem-solving approach delivered with the constructivist notion. Linking classroom mathematics to real-life activities makes learners appreciate the subject very well. Since the learners see mathematics as an of life. The study concludes that the ASA Problem Solving Process is an effective way of finding solutions to contextualized problems.

Recommendations

Based on the findings, the study recommends the following;

1. Teachers should endeavor to read around each topic to get enough practical examples for every topic they teach.
2. Teachers must ensure that their lessons are linked to real-life activities
3. Teachers must provide opportunities for all learners to learn

References

Abreh, M. K., Owusu, K. A., & Amedahe, F. K. (2018). Trends in performance of WASSCE candidates in the science and mathematics in Ghana: Perceived contributing factors and the way forward. *Journal of Education*, *198*(1), 113–123.

Adom, D., .com, A., & Ankrah, K. (2016). CONSTRUCTIVISM PHILOSOPHICAL PARADIGM: IMPLICATION FOR RESEARCH, TEACHING, AND LEARNING. *Global Journal of Arts Humanities and Social Sciences*, *4,* 1–9.

Amir, M. Z., Urrohmah, A., & Andriani, L. (2021). The effect of application of realistic mathematics education (RME) approach to mathematical reasoning ability based on mathematics self-efficacy of junior high school students in Pekanbaru. *Journal of Physics: Conference Series*, *1776*(1), 012039.

Amponsah-Tawiah, A. (2020). *An Investigation into Pupils' Experiences of Solving Non-Routine Mathematics Problems: A Case Study of Ghana International School* [Ph.D. Thesis]. The University of Ghana.

Anamuah-Mensah, J., & Mereku, D. K. (2005). Ghanaian JSS2 students' abysmal mathematics achievement in TIMSS 2003: A consequence of the primary school mathematics curriculum. *Mathematics Connection*, *5*(1), 1–13.

Apple, M. W. (2011). Paulo Freire, critical pedagogy and the tasks of the critical scholar/activist. *Revista E-Curriculum*, *7*(3), 1–21.

Arfiana, A., & Wijaya, A. (2018). Problem-solving skills of students of senior high schools and Islamic high schools in Tegal Regency in solving the problem of PISA based on Polya's stage. *Jurnal Riset Pendidikan Matematika*, *5*(2), 211–222.

Arthur, Y. D., Asiedu-Addo, S., & Assuah, C. (2017). Students' perception and its impact on Ghanaian students' interest in mathematics: Multivariate statistical analytical approach. *Asian Research Journal of Mathematics*, 1–12.

Asante, G., & Agbee, D. (2021). Responding to access and beyond in Fee-free policies: Comparative Review of Progressive Free Senior High and Free Senior High School policies in Ghana. *ScienceOpen Preprints*.

Atta, S. A., & Brantuo, W. A. (2021). Digitalizing the Teaching and Learning of Mathematics at the Senior High Schools in Ghana; the Case of Flipped Classroom Approach. *American Journal of Education and Practice*, *5*(3), 29–37.

Baah-Duodu, S., Osei-Buabeng, V., Cornelius, E. F., Hegan, J. E., & Nabie, M. J. (2020). Review of Literature on Teaching and Learning Geometry and Measurement: A Case of Ghanaian Standards Based Mathematics Curriculum. *International Journal of Advances in Scientific Research and Engineering, IJASRE (ISSN: 2454-8006)*, *6*(3), 103–124.

Baba, T., Ueda, A., Ninomiya, H., & Hino, K. (2018). Mathematics education lesson study in Japan from historical, community, institutional, and development assistance perspectives. In *Mathematics lesson study around the world* (pp. 23–45). Springer.

Barnes, H. (2005). The theory of Realistic Mathematics Education as a theoretical framework for teaching low attainers in mathematics. *Pythagoras*, *0*(61), 42–57. https://doi.org/10.4102/pythagoras.v0i61.120

Boaler, J., Chen, L., Williams, C., & Cordero, M. (2016). Seeing as Understanding: The Importance of Visual Mathematics for our Brain and Learning. *Journal of Applied & Computational Mathematics*, *05*(05). https://doi.org/10.4172/2168-9679.1000325

Butakor, P. K. (2021). Mobile Phone Use for Instructions in Senior High Schools in Ghana: Views and Opinions of University Students. *International Journal of Curriculum and Instruction*, *13*(2), 1119–1132.

Cai, J., & Wang, T. (2010). Conceptions of Effective Mathematics Teaching within a Cultural Context: Perspectives of Teachers from China and the United States. *Journal of Mathematics Teacher Education*, *13*(3), 265–287. https://doi.org/10.1007/s10857-009-9132-1

CRDD, MOE. (2017). MINISTRY OF EDUCATION. *Core Mathematics Syllabus for Senior High Schools in Ghana*, 66.

Eduafo, A. B. (2014). *Effects of problem-solving approach on mathematics achievement of diploma in basic education distance learners at the University Of Cape Coast, Ghana*. 256.

Etikan, I., Musa, S. A., & Alkassim, R. S. (2016). Comparison of convenience sampling and purposive sampling. *American Journal of Theoretical and Applied Statistics*, *5*(1), 1–4.

Freire, P. (2020). Pedagogy of the oppressed. In *Toward a Sociology of Education* (pp. 374–386). Routledge.

Fuchs, L. S., Fuchs, D., Seethaler, P. M., & Craddock, C. (2020). Improving language comprehension to enhance word-problem solving. *Reading & Writing Quarterly*, *36*(2), 142–156.

Giroux, H. A. (2010). Rethinking education as the practice of freedom: Paulo Freire and the promise of critical pedagogy. *Policy Futures in Education*, *8*(6), 715–721.

Gunasegar, D., & Maat, S. M. (2022). Teaching Mathematics Based on Graphic Management in Problem Solving Topics. *Malaysian Journal of Social Sciences and Humanities (MJSSH)*, *7*(1), 352–366.

Huinker, D. (2018). Principles to Actions: Moving to a framework for teaching mathematics. *Teaching Children Mathematics*, *25*(3), 133–136.

Knapp, N. F. (2019). The shape activity: Social constructivism in the psychology classroom. *The teaching of Psychology*, *46*(1), 87–91.

Kusuma, J. W., Rochmad, R., Isnarto, I., & Hamidah, H. (2021). Constructivism from philosophy to mathematics learning. *International Journal of Economy, Education, and Entrepreneurship*, *1*(2), 104–111.

Martin, M. O., von Davier, M., & Mullis, I. V. (2020). Methods and Procedures: TIMSS 2019 Technical Report. *International Association for the Evaluation of Educational Achievement*.

Matey, J. (2020). *The Effect of Free Senior High School Policy on the Lives of Parents and Wards in Ghana*.

Mullis, I. V., & Martin, M. O. (2019). *PIRLS 2021 Assessment Frameworks.* ERIC.

Nabie, M. J., Akayuure, P., & Sofo, S. (2013). Integrating problem solving and investigations in Mathematics: Ghanaian teachers' assessment practices. *International Journal of Humanities and Social Science*, *3*(15), 46–56.

Osanloo, A., & Grant, C. (2016). Understanding, selecting, and integrating a theoretical framework in dissertation research: Creating the blueprint for your "house." *Administrative Issues Journal: Connecting Education, Practice, and Research*, *4*(2), 7.

Putri, B. D., Handayani, N. S., Ekayafita, S. Z., & Lestari, A. D. (2021). The Indonesian Version of SF-36 Questionnaire: Validity and Reliability Testing in Indonesian Healthcare Workers Who. *Indian Journal of Forensic Medicine de Toxicology*, *15*(2), 2135.

Richardson, M., Isaacs, T., Barnes, I., Swensson, C., Wilkinson, D., & Golding, J. (2020). *Trends in International Mathematics and Science Study (TIMSS) 2019: National report for England: Research report: December 2020*.

Stinson, D. W., Bidwell, C. R., & Powell, G. C. (2012). Critical pedagogy and teaching mathematics for social justice. *The International Journal of Critical Pedagogy*, *4*(1).

Surya, Y. F., Marta, R., & Wijaya, T. T. (2020). Measurement of mathematics problems solving ability using problem-based mathematics questions. *Journal of Physics: Conference Series*, *1613*(1), 012026.

Taherdoost, H. (2016). Sampling methods in research methodology; how to choose a sampling technique for research. *How to Choose a Sampling Technique for Research (April 10, 2016)*.

Tambunan, H. (2019). The Effectiveness of the Problem-Solving Strategy and the Scientific Approach to Students' Mathematical Capabilities in High Order Thinking Skills. *International Electronic Journal of Mathematics Education*, *14*(2), 293–302.

Xie, C. (2021). What can China learn from evidence-based educational reform? A comparative review of educational technology programs' effects on mathematics achievement. *ECNU Review of Education*, *4*(1), 65–83.

Zou, Y. (2019). OECD and educational policy in China. *The OECD's Historical Rise in Education*, 155–173.