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INTEGRATING COMPUTATIONAL THINKING AND THE POLYA'S MODEL IN MINECRAFT: THE EFFECTS ON LEARNERS' FRACTIONS ACHIEVEMENT

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ABSTRACT

There are few empirical research on the influence of incorporating computational thinking and Polya's Model in digital games on the academic achievement of students and the best ways for implementing this integration. Therefore, this quasi-experimental pretest and posttest non-equivalent group design research was aimed at determining the effect of integrating computational thinking and Polya's model in Minecraft on students' fraction proficiency. Fifty-seven students from two intact classes were involved as the participants. The control group had 28 students, while the experimental group had 29 students. The findings revealed that the fraction achievement of the experimental group students increased as compared to students in the control group. It may be determined that studying fractions in Minecraft through the integration of computational thinking and Polya's model had the best influence on student's academic progress. Thus, teachers should be able to incorporate it into other materials for learning mathematics.

INTEGRASI *COMPUTATIONAL THINKING* DAN MODEL POLYA PADA *MINECRAFT*: PENGARUHNYA TERHADAP PRESTASI BELAJAR MATERI PECAHAN

Kata Kunci:

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ABSTRAK

Kajian empiris tentang pengaruh mengintegrasikan *computational thinking* dan Model Polya dalam permainan digital terhadap prestasi akademik siswa dan strategi terbaik untuk menerapkan integrasi ini masih kurang. Oleh karena itu, desain kelompok non-ekuivalen quasi-eksperimental pretest dan posttest ini bertujuan untuk mengidentifikasi pengaruh mengintegrasikan *computational thinking* dan Model Polya di Minecraft terhadap prestasi siswa dalam pecahan. Sebanyak 57 siswa dari dua kelas utuh dilibatkan sebagai sampel penelitian. Kelompok kontrol terdiri dari 28 siswa sedangkan kelompok eksperimen terdiri dari 29 siswa. Temuan penelitian ini menunjukkan bahwa prestasi pecahan siswa dalam kelompok eksperimen meningkat dibandingkan dengan siswa dalam kelompok kontrol. Dapat disimpulkan bahwa pembelajaran pecahan melalui integrasi *computational thinking* dan Model Polya di Minecraft memiliki pengaruh yang optimal terhadap prestasi akademik siswa. Untuk itu disarankan kepada pendidik untuk dapat menggunakannya dalam pembelajaran matematika pada materi lainnya.

1. INTRODUCTION

Various policies and initiatives have been implemented by the Ministry of Education of Malaysia to empower and improve the education system in the country. These efforts are driven by the rapid development of technology and the increasing use of information and communication technology (ICT) which has led to the need for the education system in Malaysia to be transformed and to keep pace with other developed countries. Problem-solving skills are essential in the future, especially in facing the challenges of the Industrial Revolution 4.0 (IR4) [1], [2]. Problem-solving is one of the fundamental human cognitive processes. It is identified as a cognitive process of the brain at a higher cognitive level that searches for a solution for a given problem or finds a path to reach a given goal [3].

The Ministry of Education has implemented a transformation in education that involves the integration of computational thinking into the primary and secondary school curriculum to instill problem-solving skills among students in Malaysia. This integration is in line with the goal of equipping learners with the skills needed to adapt, remain relevant, and thrive in meeting the demands of employment in the future [4].

The integration of computational thinking in the teaching and learning process would assist in building a foundation for learners to apply a systematic problem-solving approach and foster higher-order thinking skills [5]-[7]. Through computational thinking, learners will acquire the necessary skills to organize, analyze, and present data or ideas logically and systematically. As a result, it will in turn help in solving complex problems systematically through certain techniques, such as decomposition, pattern recognition, abstraction, and algorithm [8]. The integration of computational thinking in the education setting has been applied in various fields like science, technology, engineering, and mathematics (STEM) education [9], [10]. Currently, STEM education has become increasingly vital [11], considering that the 21st-century job market is in dire need of a skilled workforce equipped with problem-solving skills, creativity, innovation, and team players [12]. STEM education is an effective way to expose learners to problem-solving skills through investigation and exploration. This approach allows learners to develop computational thinking skills from the early stages of schooling, which are essential for success in the 21st century [13]-[17].

Fractions are a fundamental concept in mathematics that is used in a wide range of mathematical operations and real-world applications. Having a solid conceptual understanding of fractions is important for many areas of mathematics, including arithmetic, algebra [18], and geometry. Fractions allow learners to represent and compare quantities that are not whole numbers, and are key tools for understanding and solving problems involving fractions in real life such as ratios, rates, and decimals [19]-[22].

However, most learners in Malaysia struggle to understand and master the concepts of fractions despite having been exposed to the topic since their early primary years, thus impacting learners' achievement in mathematics. This statement is based on Malaysia's unsatisfactory results in the Trends in Mathematics and Science Studies (TIMSS) assessment that involves fractions [19], [23]. Table 1 shows Malaysia's average score in mathematics in TIMSS 2019. Based on the table, the average score obtained by Malaysia is below the international average score of 500. Concerning Table 2, the average score obtained by Malaysia shows that the achievement of Malaysian learners is clearly at an unsatisfactory level.

Table 1. Malaysia's Position Based on Mathematics Achievement in TIMSS 2019 [23]

Year	Average score	Position
2019	461	26 out of 36 countries

Table 2. Level of International Benchmark and Average Score [23]

Benchmark	Average score
Advanced	625
High	550
Intermediate	475
Low	400

The TIMSS mathematics assessment framework for 4th grade, which are fifth-year students in Malaysia, consists of 2 dimensions: the content and the cognitive domains. The content domain is a body of knowledge, skills, or abilities being measured in a study, experiment, or test. On the other hand, the cognitive domain refers to intellectual skills, such as critical thinking, problem-solving, and creating a knowledge base. Table 3 depicts that fractions are among the topic tested in the assessment, which indicates the importance of fractions in the assessment.

Table 3. The Percentage of Questions Allocated for Each Topic at 4th Grade in TIMSS 2019 [23]

Content Domain	Topic	Percentage	Total Percentage
Number	Integer	10%	30%
	Fractions and decimals	10%	
	Ratio, percentage, and proportion	10%	
Algebra	Expressions, operations, equations	20%	30%
	Relation and function	10%	
Geometry	Geometric shapes and measurements	20%	20%
Data and Probability	Data	15%	20%
	Probability	5%	

One of the major obstacles which contributed to Malaysia's unsatisfactory level of achievement in fractions is a misconception about fractions, which is also known as whole number bias. Whole number bias is defined as the tendency to focus on the whole number components of fractions (numerators and denominators) rather than fractions as a single number [24]-[26]. This misconception has led students to generalize the concepts of whole numbers to that of fractions; thus, resulting in learners solving the addition and subtraction of fractions by directly adding or subtracting the numerator with the numerator and the denominator with the denominator [21], [27]-[29]. They assumed that the numerator and denominator are two separate whole numbers instead of two numbers that are related to each other [30]. This issue indicates that learners had difficulties in the conceptual understanding of fractions.

To overcome this obstacle, proper methods and approaches should be emphasized and applied in the teaching and learning process since learners' academic achievement is often linked to the effectiveness of the methods and approaches practiced by teachers [31]. Therefore, taking into account that previous studies have proven the impact of ICT in teaching and learning, the use of digital games, particularly Minecraft, in the teaching and learning of fractions needs to be implemented to further strengthen the conceptual understanding of fractions among learners which in turn would assists in fractional problem-solving. Furthermore, there is a need to integrate computational thinking, particularly the concept of decomposition, in lessons that involve the use of digital games or also known as digital game-based learning. The integration of computational thinking with digital game-based learning is defined as the application of computational thinking concepts which includes decomposition, pattern recognition, abstraction, and algorithm [32] in the teaching and learning process which involves the use of digital games. Integrating the concept of decomposition with digital game-based learning would provide a step-by-step guide among learners on how to solve problems [32] which in this case

guides learners on how to systematically solve fractional problems using Minecraft. To enable learners to have a clear procedure on how to systematically solve fractional problems using decomposition, reference was made to Polya's model. Based on the model, [33] suggested four steps on how to systematically and effectively solve problems: understand the problem, devise a plan, carry out the plan, and look back and reflect.

Empirical findings regarding the effect of integrating computational thinking, which involves the concept of decomposition, with Polya's model in digital games on learners' achievement in fractions are still lacking. Therefore, this research aims to identify the effect of integrating computation thinking with Polya's model in Minecraft on Year 5 students' achievement in fractions.

Several studies on computational thinking have been carried out including computational thinking for problem-solving and higher order thinking skills [34], integrating computational thinking into STEAM to improve metacognitive [9], digital game-based learning has also been carried out including game-based learning with Minecraft [35], game-based learning with Minecraft on student achievement [36] but there has been no research that integrates computational thinking with the Polya's model in Minecraft games on learning achievement, this is a novelty in this research.

Therefore, the purpose of conducting this research is to integrate computational thinking with the models that have been prepared by Polya and the Minecraft game to become a stimulus in improving students' abilities, so that this learning is expected to be able to increase learning achievement. Different from previous research which did not integrate computational thinking with games, this research has a novelty in the form of using the game Minecraft in computational thinking.

3. METHOD

A quasi-experimental pretest and posttest non-equivalent group design was employed in this research. This research was conducted in a primary school in the Keningau district in the state of Sabah. The study population involved 57 fifth-year students in two intact classes. The researchers implemented cluster sampling to determine the samples. Twenty-eight students were selected as the control group while another twenty-nine students were selected as the treatment group. The control group was exposed to the teaching and learning of fractions using conventional methods while the treatment group was exposed to the teaching and learning of fractions using Minecraft which was integrated with computational thinking and Polya's model. The selection of fifth-year students as the study sample is to meet the criteria commonly used in the TIMSS assessment where the age of the study samples is within the range of 11 years old.

The pretest and posttest were used as instruments. The pretest was made up of 15 restricted response items developed based on the test specification table which involved the topic of fractions and was administered to identify students' prior knowledge of fractions. The posttest was administered to identify whether there was an increase in achievement among students after being exposed to the intervention. The same items were used for both instruments to ensure equal comparisons. Through a pilot test, the reliability of the pretest was determined using Cohen Kappa analysis based on the level of agreement between raters or also known as inter-rater agreement. Cohen Kappa analysis was performed to obtain a value that would show the degree of agreement between the raters [37] in giving marks to each item in the pretest. Table 4 shows the interpretation of the degree of agreement between raters based on the Cohen Kappa analysis while Table 5 shows the pretest reliability based on the Cohen Kappa index value. Based on Table 5, items in the pretest show a high-reliability value. Face validation and content validation as

also carried out to ensure the accuracy and clarity of the items as well as to ensure the items were representative of the construct.

Table 4. Cohen Kappa Interpretation [38]

Cohen Kappa Value Index	Level of Agreement
0 – .20	None
.21 – .39	Minimal
.40 – .59	Weak
.60 – .79	Moderate
.80 – .90	Strong
.90 – 1.00	Almost perfect

Table 5. Pre-test Reliability Based on Cohen Kappa Value Index [38]

Questions	Cohen Kappa Value	Level of Agreement
1	0.932	Almost perfect
2	0.948	Almost perfect
3	0.950	Almost perfect
4	0.895	Strong
5	0.895	Strong
6	0.944	Almost perfect
7	0.862	Strong
8	0.927	Almost perfect
9	0.938	Almost perfect
10	1.000	Almost perfect
11	0.925	Almost perfect
12	0.918	Almost perfect
13	1.000	Almost perfect
14	0.907	Almost perfect
15	0.912	Almost perfect

The study was carried out for seven weeks. Before the implementation of the study, the mathematics teacher involved in conducting the teaching and learning sessions using Minecraft were briefed and trained regarding the administration of the pretest, posttest, and the use of Minecraft. Discussions were also carried out between the teacher involved and the researcher regarding the concepts of computational thinking and Polya's model as well as how these two concepts will be integrated into Minecraft in solving fractional problems. The pretest was administered in the first week while the posttest was administered in the seventh week. The teaching and learning of fractions were held for five weeks starting from the second week until the sixth week. Lessons in the treatment group would involve the use of Minecraft which has been integrated with computational thinking and Polya's model while lessons in the control group would involve the use of conventional methods. Efforts were made by the researcher to control several external variables that may exert some influence on the dependent variable in the study [39]. The external variables include selection bias, history, experimenter effect, Hawthorne effect, testing effect, and situation effect.

Data were analyzed using inferential statistics which involves the dependent samples t-test and independent samples t-test. The dependent samples t-test was used to determine if there was a significant difference in the posttest mean achievement score among students in the control group and students in the treatment group. The independent samples t-test was used to determine if there was a significant difference in the posttest mean achievement score between students in the control group and students in the treatment group.

4. RESULTS AND DISCUSSION

The Shapiro-Wilk statistical test was performed to test the normality of the pretest and posttest data of the control group and the treatment group to determine whether parametric or non-parametric statistics would be used to analyze the data. Based on the analysis of the normality test of the control group, the value of .08 and the value of the post-test of .07 were obtained. Since both values were greater than the significance value of .05, the pretest and posttest data of the control group are normally distributed, thus parametric statistics were selected to analyze the data. Based on the analysis of the normality test of the treatment group, the value obtained was .08 with the value of the posttest was .06. Since both values were greater than the significance value of .65, the pretest and posttest data of the treatment group were normally distributed, thus parametric statistics were selected to analyze the data.

Next, a hypothesis test was performed regarding the effect of integrating computational thinking with Polya's model in Minecraft on learners' achievement in fractions through the following hypothesis.

$H_0$1: There is no significant difference between the pretest and posttest mean achievement scores in the control group

Table 6 shows that the p-value is .19, which is greater than the significance level of .05. Therefore, the null hypothesis fails to be rejected. It means that there is no significant difference between the pretest mean achievement score and the posttest mean achievement score for the control group ($t(34) = -1.34$, $p = .19$). This finding indicates that conventional methods of teaching and learning fractions have had limited success in improving students' achievement scores.

Table 6. The Comparison of the Pre-Test and Post-Test Mean Achievement Score for the Control Group

	N	Mean	Standard Deviation	Mean Difference	t-value	df	Sig. (2-tailed)
Pretest score	28	6.03	2.76	-.17	-1.34	34	.19
Posttest score		6.20	2.79				

Significant at $p < .05$

$H_0$2: There is no significant difference between the pretest and posttest mean achievement scores in the treatment group

Based on Table 7, $p = .00$ is less than the significance level of .05. Therefore, the null hypothesis is rejected. There is a significant difference between the pretest mean achievement score and the posttest mean achievement score for the treatment group ($t(30) = -4.04$, $p = .00$). This indicates that the use of Minecraft in the teaching and learning of fractions, combined with computational thinking and the Polya's model, has resulted in improved achievement scores among students.

Table 7. The Comparison of the Pre-Test and Post-Test Mean Achievement Score for the Control Group

	N	Mean	Standard Deviation	Mean Difference	t-value	df	Sig. (2-tailed)
Pretest score	29	6.93	3.15	-1.87	-4.04	30	.00
Posttest score		8.80	2.76				

Significant at $p < .05$

$H_0$3: There is no significant difference between the posttest mean achievement score for the control group and the posttest mean achievement score for the treatment group

Levene's test for equality of variances in Table 9 which was not significant ($p = .78 > .05$) showed that both the control group and the treatment group have equal variances. The null

hypothesis fails to be rejected, so the results of the t-test for the mean comparison of the two groups of independent samples that have the same variance are considered (equal variances assumed). Based on Table 9, p = .00 is less than the .05 significance level. Therefore, the null hypothesis is rejected. There is a significant difference between the post-test mean achievement score of the control group and the post-test mean achievement score of the treatment group (t(63) = -3.60, p = .00). This indicates that the use of Minecraft, combined with computational thinking and the Polya's model, has been effective in improving students' achievement scores in fractions. The higher posttest mean achievement score of the treatment group, compared to the control group, provides evidence that this approach has had a positive impact on students' learning outcomes.

Table 8. The Comparison of the Post-Test Mean Achievement Score between the Control Group and the Treatment Group

	Group	N	Mean	Standard Deviation	Standard Error of the Mean
Posttest score	Treatment group	28	6.20	2.79	3.11
	Control group	29	8.80	2.77	3.09

Table 9. Independent Sample Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Posttest marks	Equal variances assumed	.07	.78	-3.60	63	.00	-15.86	4.40	-24.66	-7.06
	Equal variances not assumed			-3.61	62.89	.00	-15.86	4.39	-24.64	-7.08

Significant at p < .05

The findings of the study have proven the positive impact of incorporating computational thinking and Polya's model into a Minecraft-based approach in the teaching and learning of fractions. The significant improvement in the posttest achievement scores of the treatment group compared to the control group provides evidence of the effectiveness of this approach. This is in line with previous studies by [40]-[42] which emphasize the importance of integrating computational thinking into the teaching and learning environment to improve students' problem-solving skills.

On how this approach can improve problem-solving skills among students, particularly in regards to fractions, this research found that the integration of computational thinking, specifically the concept of decomposition, and Polya's model into a Minecraft-based approach to the teaching and learning of fractions have helped students to solve fractional problems more systematically and effectively. By constructing and manipulating fraction models in Minecraft, students were able to gain a clearer view understanding of the value of fractions, which helped strengthen their conceptual understanding of fractions [36]. Additionally, the integration of Polya's model provided students with a structured problem-solving process that breaks down complex problems into four steps [33].

The use of digital games, such as Minecraft, has been proven through this research to be an effective way to introduce computational thinking skills to students [43]. Furthermore, the use of Minecraft in the teaching and learning of fractions allows for hands-on problem-solving activities, which have several benefits for students learning. Hands-on activities provide students with real learning experiences regarding a concept, skill, or idea and allow students to better understand the concept, skill, or idea [44], [45]. In addition to providing a more realistic and interesting learning experience [46], [47]. Hands-on activities are also capable of triggering students' curiosity, thus encouraging students to conduct investigations and explorations when carrying out those activities [48] as well as improving students' skills in the subject. Additionally, hands-on activities allow students to form new knowledge and relate it to existing knowledge, which can provide a more comprehensive understanding of mathematical concepts [49], [50].

The use of Minecraft in activities involving mathematics has improved the effectiveness of the teaching and learning of mathematics by providing a visually stimulating and interactive platform for students to learn mathematical concepts [51], [52]. The ability to manipulate virtual blocks in Minecraft to build fractions and solve problems has made abstract concepts of fractions more accessible and tangible for students, which has improved their understanding and retention of information regarding fractions. Furthermore, this research has emphasized the need to provide digital-oriented teaching materials to support students' problem-solving skills [53], [54]. With the increasing reliance on technology in almost all aspects of our lives, students must develop digital literacy skills early on in their education.

5. CONCLUSION

By providing a structured approach to problem-solving and by implementing Polya's model, computational thinking has the potential to improve students' problem-solving skills. As a plus, the integration of Polya's model with computational thinking in Minecraft will enhance the problem-solving process by empowering students to break down complex problems into smaller parts and find effective and systematic solutions. This combination of computation thinking and Polya's model can help students develop a more comprehensive and systematic approach to solving problems.

REFERENCES

[1] Gray, "The 10 Skills You Need to Thrive in the Fourth Industrial Revolution", *Word Economic Forum*, 2016, [Online]. Available: https://www.weforum.org/agenda/2016/01/the-10-skills-you-need-to-thrive-in-the-fourth-industrial- revolution/. [Accessed: 11-January-2023].

[2] F. M. Kamaruzaman, R. Hamid, and A. A. Mutalib, "Conceptual framework for the development of 4IR skills for engineering graduates", *Global Journal of Engineering Education*, vol. 21, no. 1, pp. 54 – 61, 2019.

[3] Y. Wang, "The theoretical framework of cognitive informatics", *International Journal of Cognitive Informatics and Natural Intelligence*, vol. 1, no. 1, pp. 1 – 27, 2007.

[4] K.P. Malaysia, *Laporan TIMSS 2015 (Trends in International Mathematics and Science Study*. Putrajaya: Bahagian Perancangan dan Penyelidikan Dasar Pendidikan, 2016.

[5] J. Naughton, "Why All Our Kids Should Be Taught How to Code", *The Guardian*, vol. 31, no. 1, pp. 113-114, 2012.

[6] G. Falloon, "An analysis of young students' thinking when completing basic coding tasks using Scratch Jnr. On the ipad", *Journal of Computer Assisted Learning*, vol. 32, no. 6, pp. 576 – 593, 2016.

[7] Á. Molina-Ayuso, N. Adamuz-Povedano, R. Bracho-López, and M. Torralbo-Rodríguez, "Introduction to Computational Thinking with Scratch for Teacher Training for Spanish Primary School Teachers in Mathematics", *Education Sciences*, vol. 12, no. 12, pp. 1-13, 2022.

[8] G. Chen, J. Shen, L. Barth-cohen, S. Jiang, X. Huang and M. Eltoukhy, "Computers & Education Assessing Elementary Students' Computational Thinking in Everyday Reasoning and Robotics Programming", *Computing Education*, vol. 109, no.1, pp. 162 – 175, 2017.

[9] N. Markandan, K. Osman and L. Halim, "Integrating Computational Thinking and Empowering Metacognitive Awareness in Stem Education", *Frontiers in Psychology*, vol. 9, no. 13, pp. 1-18, 2022.

[10] J. F. Sanford and J. T. Naidu, "Computational Thinking Concepts for Grade School", *Contemporary Issues in Education research*, vol, 9, no. 1, pp. 23 – 32, 2016.

[11] Y. Li, K. Wang, Y. Xiao and J. E. Froyd, "Research and trends in STEM education: a systematic review of journal publications", *International Journal of STEM Education*, vol. 7, no. 1, pp. 1-16, 2020.

[12] M. S. Rasul, L. Halim and Z. Iksan, "Using Stem Integrated Approach to Nurture Students' Interest and 21st Century Skills", *The Eurasia Proceedings of Educational & Social Sciences*, vol. 4, no.1, pp. 313 – 319, 2016.

[13] J. del Olmo, R. C. Cózar-Gutiérrez, J. A. González-Calero, J. del Olmo-Muñoz, R. Cózar-Gutiérrez and J. A. González-Calero, Computational thinking through unplugged activities in early years of Primary Education", *Computing Education*, vol. 150, no. 1, pp. 1-19, 2020.

[14] H. Haslina, A. Aliza, P. Lye Guet and M. H. Mohd Saferi, *Using Scratch Programming To Engage Primary School Penggunaan Scratch Programming Untuk Meningkatkan Penglibatan Murid Sekolah Rendah*. Bangi: Universiti Kebangsaan Malaysia, 2018.

[15] A. Otterborn, K. J. Schönborn and M. Hultén, "Investigating preschool educators' implementation of computer programming in their teaching practice", *Early Childhood Education Journal*, vol. 48, no. 3, pp. 253 – 262, 2022.

[16] S. Papadakis and M. Kalogiannakis, *Evaluating a course for teaching advanced programming concepts with scratch preservice kindergarten teachers: a case study in Greece, In Early Childhoos Education, eds. D. Farland-Smith*. Hoboken, NJ: Wiley, 2019.

[17] M. Yağcı, "A Valid and Reliable Tool for Examining Computational Thinking Skills", *Education and Information Technologies*, vol. 24, no. 1, pp. 929 – 951, 2018.

[18] J. L. Booth, K. J. Newton and L. K. Twiss-Garrity, "The impact of fraction magnitude knowledge on algebra performance and learning", *Journal of Experimental Child Psychology*, vol.118, no. 1, pp. 110 – 118, 2014.

[19] A. H. Abdullah, N. L. Z. Abidin and M. Ali, "Analysis of Students' Errors in Solving Higher Order Thinking Skills (HOTS) Problems for the Topic of Fraction", *Asian Social Science*, vol. 11, no. 21, pp. 133 – 142, 2015.

[20] J. L. Booth and K. J. Newton, "Fractions: Could they really be the gatekeeper's doorman?", *Contemporary Educational Psychology*, vol. 37, no. 4, pp. 247 – 253, 2012.
[21] J. Ndalichako, "Analysis of Students' Difficulties in Solving Questions Related to Fractions: The Case of Primary School Leaving Examination in Tanzania", *Creative Education*, vol. 4, no. 9, pp. 69 – 73, 2013.
[22] A. Wijaya, "The relationships between Indonesian fourth graders' difficulties in fractions and the opportunity to learn fractions: A snapshot of TIMSS results", *International Journal of Instruction*, vol. 10, no. 4, pp. 221 – 236, 2017.
[23] I. V. S. Mullis, M. O. Martin, P. Foy, M. Hooper, D. L. Kelly and B. Fishbein, *TIMSS 2019 International Results in Mathematics and Science*. Chestnut Hill, MA: Boston College, 2020.
[24] S. J. Lamon, *Tecahing Fractions and Ratios for Understanding: Essential Content Knowledge and Instructional Strategies for Teachers*. (2nd ed.) New Jersey: Lawrence Erlbaum Associates, 2008.
[25] Y. Ni and Y.-D. Zhou, Y.-D, "Teaching and Learning Fraction and Rational Numbers: The Origins and Implications of Whole Number Bias", *Educational Psychologist*, vol. 40, no. 1, pp. 27 – 52, 2005.
[26] J. V. Walle, K. Karp, J. B. Williams, A. Brass, B. Bently, S. Ferguson, W. Goff, S. Livy, M. Marshman, D. Martin, C. Pearn., T. Prodromou, D. Symons and K. Wilkie, *Primary and Middle Years athematics: Teaching Developmentally*, (1st ed.). Melbourne: Pearson, 2019.
[27] Z. B. Dhlamini and I. Kibirige, "Grade 9 learners' errors and misconceptions in addition of fractions", *Mediterranean Journal of Social Sciences*, vol. 5, no. 8, pp. 236 – 244, 2014.
[28] H. C. Li, "A comparative analysis of British and Taiwanese students' conceptual and procedural knowledge of fraction addition", *International Journal of Mathematical Education in Science and Technology*, vol. 45, no. 7, pp. 968 – 979, 2014.
[29] Y. Loong, "Fostering mathematical understanding through physical and virtual manipulatives", *The Australian Mathematics Teacher*, vol. 70, no. 4, pp. 3 – 10, 2014.
[30] M. DeWolf and S. Vosniadou, "The representation of fraction magnitudes and the whole number bias reconsidered", *Learning and Instruction*, vol. 37, no. 1, pp. 39 – 49, 2015.
[31] E. Zakaria & N. Addenan, *Isu Pengajaran Dalam Kalangan Guru Matematik.* Kuala Lumpur : Fakulti Pendidikan Universiti Kebangsaan Malaysia, 2015.
[32] S. B. Zaibon and E. Yunus, "The Effectiveness of Game-Based Learning Application Integrated with Computational Thinking Concept for Improving Student's Problem-Solving Skills. *Springer International Publishing*, vol. I, no. 1, pp. 429-442, 2022.
[33] G. Polya, *Mathematical Discovery: On Understanding, Learning and Teaching Problem Solving.* New York: Wiley, 1981.
[34] N. L. Zaharin, S. Sharif and M. Mariappan, "Computational Thinking: A Strategy for Developing Problem Solving Skills and Higher Order Thinking Skills (HOTS)", *International Journal of Academic Research in Business and Social Sciences*, vol. 8, no. 10, pp. 1265 – 1278, 2018.

[35] H. C. Lane, S. Yi, B. Guerrero and N. Comins, "Minecraft as a sandbox for STEM interest development: Preliminary results", *Proceedings of the 25th International Conference on Computers in Education*, vol. I, no. 1, pp. 387 – 397, 2017.
[36] R. Tangkui and T. C. Keong, "The Effects of Digital Game-Based Learning Using Minecraft Towards Students' Achievement in Fraction", *International Journal of e-Learning Practices*, vol. 4, no. 1, pp. 76 – 91, 2021.
[37] J. Landis and G. Koch, "The measurement of observer agreement for categorical data", *Biometrics*, vol. 33, no. 1, pp. 159 –174, 1977.
[38] M. McHugh, "Interrater reliability: The Kappa Statistic", *Biochemia Medica*, vol. 22, no. 3, pp. 276 – 282, 2012.
[39] M. A. Handley, C. R. Lyles, C. McCulloch and A. Cattamanchi, "Selecting and Improving Quasi-Experimental Designs in Effectiveness and Implementation Research", *Annual Review of Public Health*, vol. 39, no. 1, pp. 5 – 25, 2018.
[40] A. Saad, "Students' computational thinking skill through cooperative learning based on hands-on, inquiry-based, and student-centric learning approaches", *Universal Journal of Educational Research*, vol. 8, no. 1, pp. 290 – 296, 2020.
[41] U. L. Ling, T. C. Saibin, N. Nasrah, J. Labadin and Norazila Abdul Aziz, "An Evaluation Tool To Measure Computational Thinking Skills: Pilot Investigation", *Proceeding NAMSCA* 1, vol. 1, no. 1, pp. 606 - 614, 2018.
[42] S. M. S. Azman, M. Arsat and H. Mohamed, "The framework for the integration of computational thinking in ideation process", *Proceeding of The 2017 6th IEEE International Conference on Teaching Assessment and Learning for Engineering*, vol. 1, no. 1, pp. 61-65, 2018.
[43] J. Lockwood and A. Mooney, "Computational Thinking in Education : Where does it fit A systematic literary review", Maynoth: Maynooth University, 2017.
[44] S. E. Cooperstein and E. Kocevar-Weidinger, "Beyond active learning: A constructivist approach to learning", *Reference Services Review*, vol. 32, no. 2,141–148, 2004.
[45] F. J. Rutherford, "Hands-on: a means to an end". *Project 2061 Today*, 3, 2008.
[46] S. Franklin and M. Peat, "Virtual versus real: an argument for maintaining diversity in the learning environment", *International Journal of Continuing Engineering Education and Life Long Learning*, vol. 15, no. 1, pp. 67–78, 2005.
[47] M. Nott and J. Wellington, "When the black box springs open: practical work in schools and the nature of science", *International Journal of Science Education*, vol. 18, no. 7, pp. 807 – 818, 1996.
[48] K. Kartono, "Hands on activity pada pembelajaran geometri sekolah sebagai assesmen kinerja siswa", *Jurnal Kreatif Inovatif*, vol. 1, no. 1, pp. 21 – 32, 2010.
[49] M. Boggan, S. Harper and A. Whitmire, "Using manipulatives to teach elementary mathematics", *Journal of Instructional Pedagogies*, vol. 3, no. 1, pp. 1 – 6, 2010.
[50] C. A. Kelly, "Using Manipulatives in Mathematical Problem Solving: A Performance Based Analysis", *The Montana Mathematics Enthusiast*, vol. 3, no. 2, pp. 184 – 193, 2006.
[51] Y. R. Kim and M. S. Park, "Creating a Virtual World for Mathematics", *Journal of Education and Training Studies*, vol. 6, no. 12, pp. 172 – 183, 2018.
[52] R. Tangkui and T. C. Keong, "Enhancing Students' Higher Order Thinking Skills Through the Lens of Activity Theory: Is Digital Game-Based learning Effective?", *International Journal of Advanced Research in Education and Society*, vol. 2, no. 4, pp. 1– 20, 2020.

[53] W. Widya, R. Adriani, S. Sudirman, A. T. Hidayat and N. Elisyah, "The Effectiveness of Physics E-Modules Based on Creative Problem-Solving Learning Model Integrated With 21st Century Skills", *Indonesian Journal of science and Mathematics Education*, vol. 6, no. 1, pp. 48 – 58, 2023.

[54] M. Sari, D. Andra, I. W. Distrik, and K. S. Aleksandervic, "Problem-Based E-Module Integrated with STEM and Assisted by LMS to Foster Creative Thinking Ability," *Indonesian Journal of science and Mathematics Education.*, vol. 5, no. 2, pp. 224 – 237, 2022.