Scientechno: Journal of Science and Technology, 3(1) - April 2024 105-117

Constructing Realistic Mathematics Learning Assisted by Augmented Reality Technology to Improve Students' Mathematical Creative Thinking Ability Students' Mathematical Creative Thinking

Fadila Annura Hurulean [1], Bety Miliyawati [2]
[1] *Universitas Khairun, Indonesia*
[2] *Universitas Subang, Indonesia*

Corresponding Author: Name, Fadila Annura Hurulean E-mail; dilaannura@gmail.com

Article Information:
Received April 9, 2024
Revised April 18, 2024
Accepted April 21, 2024

ABSTRACT

This article presents the results of quasi-experimental research with posttest control group design that examines the context of realistic mathematics assisted by Augmented Reality Technology (ART) on students' mathematical creative thinking skills. The population in this study were all public elementary school students in Ternate City. The sample involved 110 fourth grade students from two high and medium school level elementary schools. The instruments used were initial mathematical ability test, mathematical creative thinking ability test and student attitude scale. The research data for pretest, post-test, and normalized gain scores of mathematical creative thinking ability were analyzed by two-way ANOVA and Mann-Whitney and post hoc test of One-Way ANOVA. The assumptions of normality and homogeneity of variance were performed first before using this combined statistical test. The results showed that students who received learning through Realistic mathematics context assisted by Augmented Reality Technology (ART) were significantly superior to the improvement of mathematical creative thinking skills compared to students who received Ordinary Learning (OL). The results of this study also found that there was no interaction between Mathematical Creative Thinking Ability (MCTA) and students' attitude scale in terms of both school levels.

Keywords: *Augmented Reality, Mathematical Creative Thinking, Realistic Math Context*

Journal Homepage https://journal.ypidathu.or.id/index.php/Scientechno

How to cite: Hurulaen, F, A., & Miliyawati, B. (2024). Constructing Realistic Mathematics Learning Assisted by Augmented Reality Technology to Improve Students' Mathematical Creative Thinking Ability Students' Mathematical Creative Thinking. *Scientechno: Journal of Science and Technology*, 3(1). https://doi.org/10.55849/Scientechno.v3i1.788
Published by: Yayasan Pendidikan Islam Daarut Thufulah

INTRODUCTION

The development of science and technology today requires a change in human mindset to be able to compete from various changing world situations. This demand is in line with the post-rolling goal of the Merdeka Learning Curriculum, which is to prepare the nation's young generation to have the ability to live as individuals and citizens who are productive, creative, innovative, and effective and able to contribute to the life of society, nation and state towards the success of the Golden Indonesia in 2045 (Bush, 2021; Dewantara dkk., 2023; L. Zhao dkk., 2021). On the other hand, in the arena of pluralistic life in this competitive world, the Indonesian nation needs to emerge as a nation to be reckoned with.

According to Herman (2016), one of the efforts that can be made to improve human resources is to improve the quality of education that focuses on developing students' thinking skills. In other words, critical, creative, systematic, and logical thinking can be developed through mathematics education. This is very possible because mathematics has a structure with a strong and clear relationship with one another and a consistent pattern of thinking (Andrews, 2022; Feppon dkk., 2020; Sellali & El Houda Lahiouel, 2022). Meanwhile, Permen No. 22 of 2006, states that mathematics subjects need to be given to all students starting from elementary school to equip students with the ability to think logically, analytically, systematically, critically, and creatively, as well as the ability to work together. One of the characteristics of mathematics is that it has abstract objects. This abstract nature causes many students to experience difficulties in mathematics. Students' mathematics achievement both nationally and internationally has not been encouraging (Han dkk., 2022; Lungu dkk., 2021; Mahmudah & Yazid, 2020). This can be seen from the scores of students' mathematics skills which are still below the average score of ASEAN countries and the average score of the OECD (2019). This is also reinforced by the results of the Minimum Competency Assessment (AKM) for the elementary level organized by the Indonesian government in 2022 showing that nationally students' mathematics abilities are below the minimum ability (Borda dkk., 2020; Hilario dkk., 2022; Oppong-Gyebi dkk., 2023). Zulkardi (2010) said that most students have difficulty in applying mathematics to real life situations, this is what makes it difficult for students to understand mathematics.

One of the very important abilities in mathematics, which needs to be given to students, is the ability to think creatively mathematically (Davila Delgado dkk., 2020; Doolani dkk., 2020; Iwanaga dkk., 2021). Anoiko (2011) said that mathematical creative thinking skills need to be given to all students starting from elementary school to equip students as demanded after the roll-out of the Merdeka learning curriculum. Another author, Umar (2013) states that mathematical creative thinking ability is the ability to think in solving non-routine problems that reflect aspects of sensitivity, fluency, flexibility, novelty, and elaboration. Meanwhile, according to Livne (Ibrahim & Widodo, 2020; Newton dkk., 2022; Vizgin & Institute of Philosophy, Russian Academy of Sciences, 2021), mathematical creative thinking refers to the ability to

produce varied solutions that are new to open-ended mathematical problems. Therefore, in this study, the indicators of mathematical creative thinking ability developed are fluency, namely students can answer more than one problem and flexibility indicators, namel y students can solve various problems.

Mathematical creative thinking ability cannot be measured directly. According to Worthington (2006), we measure students' creative thinking ability by exploring students' work that represents their creative thinking process. In line with this, according to McGregor (2007), we can measure students' mathematical creative thinking ability based on what students communicate verbally or in writing which can be in the form of student work related to assignments, problem solving, or students' oral answers to teacher questions. But in reality, there are still many students who have difficulty in solving problems, which are commonly used in the Final Semester Exam (FSE) (K. Goyal & Kumar, 2021; M. Goyal dkk., 2022; Ullah dkk., 2020). Even though most of the FSE questions in mathematics are routine questions. If students already have difficulty in solving routine problems, then it can be predicted how students' ability to solve non-routine problems, such as mathematical creative thinking ability questions. This fact shows that the weak mathematical creative thinking ability of students is a common phenomenon in learning mathematics at school.

Goretti (2014) said the cause of the low quality of mathematics education in Indonesia is the learning used by teachers and favored by teachers until now is expository learning (ordinary). On the one hand, the emphasis in the learning process that occurs in schools is too much on the doing aspect, but still less on the thinking aspect. What is taught at school has a lot to do with manipulative skill issues, meaning how students do math problems using this and that procedure but without explaining why the procedure is used and what its implications are (Chettri & Bera, 2020; ElShishtawy dkk., 2022; Y. Zhao dkk., 2022). As a result, students assume that in solving math problems, it is enough to choose a solution procedure that is suitable for the given problem. So, the focus of teacher learning is not on why that particular procedure is used to solve, but which procedure is chosen to solve the problem and on how to solve with that procedure. With the emphasis of learning only on manipulative skills and procedures, students' ability to think mathematically will not develop optimally.

The low mathematical creative thinking ability of students is certainly a problem that needs to be solved together by various stakeholders, especially in the field of mathematics education. This means that the role of teachers in efforts to improve and increase students' mathematical creative thinking skills is crucial. Operationally, teachers have more time and space with students in classroom learning activities, so it is important for teachers to be able to plan fun learning treatments that have an impact on improving students' mathematical creative thinking skills (Fineldi dkk., 2024; Loureiro dkk., 2020; Lu & Zheng, 2020). The selection, planning, and implementation of the intended learning treatment certainly cannot be done spontaneously or carelessly. In this case, mathematics learning must accommodate the formation of students' mathematical

creative thinking skills, because this ability is very essential and useful for students now and in the future.

On the other hand, the realistic mathematics approach assisted by Augmented Reality Technology (ART) as a learning medium can be used as a visual aid to model geometric shapes that are visually displayed in 3- dimensional space. Relistic Mathematics Learning is one of the mathematics learning models developed to bring mathematics closer to students. The steps of realistic mathematics learning according to Amin (in Hulukati, 2014) there are six stages of realistic mathematics learning, namely: 1) Conditioning students to learn; 2) Presenting contextual problems; 3) Guiding students to solve contextual problems; 4) Asking students to present problem solving or completion; 5) Comparing and discussing problem solving or completion, 6) Negotiating or discussing. Rachmawati et al., (2020) said that Augmented Reality (AR) technology used as learning media can create a new, more interactive atmosphere in learning mathematics for students. Thus, ART-assisted realistic mathematics learning is very useful in interactive learning for students. In addition, Realistic Mathematics Learning (RML) assisted by ART media can increase student interest in learning because of the nature of augmented reality that combines the virtual world that can increase student imagination with the real world directly. In this case, realistic mathematics learning assisted by ART, allows students to see real situations, live and imagine the results of the learning process presented by the teacher to students. Thus, the purpose of this study is focused on a comprehensive description of realistic mathematics learning assisted by Augmented Reality Technology (ART) on the mathematical creative thinking ability (MCTA) of elementary school students in terms of both school levels. In other words, is there a difference in the improvement of mathematical creative thinking ability of elementary school students who get realistic mathematics learning assisted by ART with ordinary learning. The hope of the results of this study is not onlyto provide general information related to students' mathematical creative thinking ability, but it is also expected to be a reference and consideration for teachers and further researchers in determining the right learning strategy for students to improve other mathematical abilities.

RESEARCH METHODOLOGY

The research method used was quasi-experiment, with a pretest-posttest control group design. The population in this study were all fourth grade public elementary school students in the odd semester of the 2022/2023 academic year in Ternate City. This research design is illustrated as follows: X - O and O - O, where (O) describes the pretest-posttest, while (X) describes realistic math learning assisted by Augmented Reality Technology (ART) and Ordinary Learning (OL) or Conventional.

The sample involved 110 students from two public elementary schools in Ternate City, which were distributed in two elementary schools based on the school level between the experimental and control classes. Samples were selected using random sampling technique, which is done without randomizing individuals, still following the

existing class. The schools were SD Negeri 2 Kota Ternate as the experimental class and SD Negeri 47 Kota Ternate as the control class. The experimental class means students who get Realistic Mathematics Learning (RML) assisted by ART and control class students who get Ordinary Learning (OL).

The instruments used in this study include mathematical creative thinking ability test items (MCTA) and student attitude scale guidelines. Observation data was obtained from a student attitude scale questionnaire given at the end of the lesson. Furthermore, the data were analyzed quantitatively and the statistical tests used were t-tests, Mann-Whitney tests, and two-way anova tests. To determine the average increase in students' MCT ability, namely by using the mastery level and normalized gain test (N-Gain) first, before using this combined statistical test.

RESULT AND DISCUSSION

RESULT

1. Analysis of Students' Mathematical Creative Thinking Ability (MCTA)

The results of the data analysis of the MCTA of experimental and control class students consisting of pretest data, normality test data, and two mean difference test data based on learning can be shown in the table below.

Table 1. Recap of Pretest Test Results of Students' MCT Ability

School Level	**Learning**	**N**	**Pretest Score**		**Normality**	**Mean Difference Test (*Mann-Whitney Test*)**
			Average	SB		
High	RML assisted ART	30	6,46	2,67	abnormal	Significantly different
	OL	28	8,73	3,77	Normal	
Medium	RML-assisted ART	26	4,68	3,10	Not normal	Not significantly different
	PB	26	4,84	3,32	Not normal	

From Table 1, it shows that for the high school level, the mean pretest of students in the control class who received ordinary or conventional learning (OL) was higher than the experimental class that received RML assisted by ART, while for the medium school level, the mean pretest of experimental class students was not much different from students who received OL. In addition, the normality test results for the high school level in the experimental class showed a probability value (sig. 2-tailed) less than the significance level of α = 0.05, which means that the data is not normally distributed, while for the control class the probability value (sig. 2-tailed) is more than the level of significance α =

0.05, which means that the data is normally distributed. For the medium school level, both classes were not normally distributed. Because one of the data or both are not normally distributed, then to test the difference between the two means using the Mann-Whitney non-parametric statistical test, from the calculation results for the high school level the probability value (sig. 2-tailed) is less than the significance level α = 0.05, which means there is a difference between students who get RML assisted by ART on improving the ability of MCT with control class students who get OL, while for the medium school level the probability value (sig. 2-tailed) is obtained more than the significance level α = 0.05, which means there is no difference between students who get RML assisted by ART and students who get OL (ordinary learning).

Table 2: Recap of MCTA Student Posttest Results

School Level	**Learning**	**N**	**Posttest Score**		**Normality**	**Mean Difference Test (*Mann-Whitney Test*)**
			Average	SB		
High	RML-assisted ART	30	56,76	9,17	abnormal	Significantly different
	OL	28	45,28	7,15	Not normal	
Medium	RML-assisted ART	26	64,73	9,81	Normal	Significantly different
	OL	26	45,35	9,85	Not normal	

Based on the data in Table 2 above, it is known that for high school level, the average MCT ability of the group of students who received RML learning assisted by ART was 56.76 higher than that of students who received OL of 45.28. Similarly, for the medium school level, the mean of MCT ability of the group of students who received ART-assisted RML learning was 64.73 higher than that of students who received OL of 45.35. After testing the difference between the two means of the four sample groups, it was found that both school levels, both high and medium school levels, obtained significant differences in the ability of MCTA between students who received Realistic mathematics learning assisted by ART and students who received OL.

Table 3. Recap of N-Gain Data Test Results of Students' MCT Ability

School Level	**Learning**	**N**	**N-gain**		**Statistical Test**	**Mean Difference Test (*Mann-Whitney Test*)**
			Average	**SB**	**Normality**	

High	RML-assisted ART	30	0,54	0,09	Normal	Significantly different
	OL	28	0,46	0,07	Not Normal	
Medium	RML-assisted ART	26	0,58	0,104	Normal	Significantly different
	OL	26	0,38	0,095	Not normal	

In Table 3 above, it shows that for high school level and medium school level, there is a difference in the improvement of MCT ability of students who get Realistic mathematics learning assisted by ART with students who get OL. That is, the improvement of students' MCT ability who received Realistic mathematics learning assisted by ART is better than students who received OL in terms of high school level and medium school level.

2. Student Attitude Questionnaire Analysis

The following are the results of data analysis of the achievement of filling out student attitude questionnaires based on school level for experimental class students who get RML assisted by ART and control class students who get OL consisting of pretest data, normality test data, and two mean difference test data based on learning, can be presented in the table below.

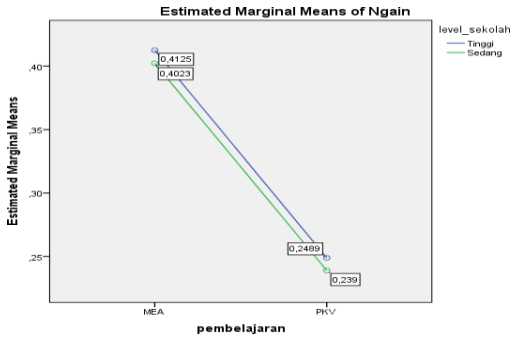
Table 4. Recap of Student Attitude Scale N-Gain Data Test Results

Level School	Learning	N	N-gain		Statistical Test	Mean Difference Test (Mann-Whitney Test)
			Average	SB	Normality	
High	RML-assisted ART	30	0,54	0,09	Normal	Significantly different
	OL	28	0,46	0,07	Not Normal	
Medium	RML-assisted ART	26	0,59	0,104	Normal	Significantly different
	OL	26	0,38	0,095	Abnormal	

From the statistical test results, it appears that for high school level, the improvement of students' attitude scale is significantly different, meaning that the improvement of the attitude of the group of students who get RM assisted by ART is better than the group of students who get OL. In contrast to the medium school level, where the improvement of students' attitudes is not significantly different, meaning that the improvement of the attitudes of students who get RML assisted by ART is not different from the group of students who get OL or conventional.

3. Interaction between RML-assisted ART to Improve MCT Skills and School Level on Student Attitude Scale

To determine whether or not there is an interaction effect between learning and school level (high and medium) on improving student attitudes, a two-way ANOVA statistical test was conducted. This is based on the basic assumption



that if the data is normally distributed, it is necessary to conduct a two-way ANOVA test. However, based on the previous data, it shows that the average improvement in student attitudes based on school level is not normally distributed, so the two-way ANOVA test cannot be carried out. Thus, the analysis of the interaction effect on student attitude improvement data was carried out descriptively from the resulting graph. The results are as follows.

From the graph above, it shows that at each school level, students who received RML assisted by ART (augmented reality technology) had better MCTA improvement than students who received OL. However, the difference between RML-assisted ART and OL at both school levels is relatively the same. At the high school level, the difference in the improvement of MCTA between students who received RML-assisted ART and those who received OL was 0.164. While at the medium school level, the difference in the improvement of MCT ability between students who received RML-assisted ART and OL was 0.163. The difference in the improvement of students' MCTA at both school levels between students who received RML-assisted ART and students who received OL was relatively the same. This is evident from the line graph, which shows that the mean improvement of students' MCTA of students who received RML-assisted ART is more than the mean improvement of students' MCTA of students who received OL.

From the line graph, it can also be seen that the means for the two lessons are relatively different and do not intersect, but the behavior of the two line graphs gives a real influence on the improvement of students' MCT skills. This indicates that RML-assisted ART for students at high school level tends to benefit more than students at medium school level in improving students' MCT skills. Thus it can be concluded that there is no significant interaction effect between the two lessons and the two school levels on the improvement of

students' MCT skills. So it is more appropriate that RML assisted by ART can be used for high school level students rather than students at moderate school level in improving students' MCT skills.

DISCUSSION

This study is generally intended to improve the cognitive and affective abilities of elementary school students through the implementation of RML assisted by Augmented Reality Technology (ART). While the purpose of this study is to comprehensively describe the improvement of MCT skills and foster attitudes of students who get RML and students who get OL models in terms of: students' Initial Mathematical Abilities (IMA) namely high, medium and low; school level (high and medium) and the overall impact of this research. Thus, the results showed that students who received RML assisted by ART were better in developing MCT skills along with students' curiosity attitude towards mathematics. In other words, the role of RML assisted by ART is superior to ordinary learning (OL) in developing students' MCT skills. This is as the results of the N-Gain data analysis of students' MCT abilities presented in Table 3 above, showing that the average increase in experimental class students who received RML assisted by ART was greater than that of control class students who received the OL model. Meanwhile, the indicators of students' MCT skills developed are presented in Table 5 below:

Table 5: Indicators of Students' MCT Ability

Indicators of Mathematical Creative Thinking Ability	**Score**	**Learning Model**					
		RML Assisted ART			**Ordinary Learning (OL)**		
		Average		**N-Gain**	**Average**		**N-Gain**
		Pretest	**Postest**		**Pretest**	**Postest**	
Students are able to develop ideas in solving problems related to Flat Buildings material	15	2,25	7,1	0,62	1,51	4,20	0,31
Students are able to find original solutions to problems related to Flat Buildings material.	15	2,6	8,5	0,79	1,61	4,30	0,32
Students are able to provide a variety of correct answers from problems related to Flat Buildings material.	20	0,5	2,3	0,19	0,41	2,69	0,23
Total	50	1,055	4,025	0,276	0,897	2,692	0,197

Based on Table 5 above, it shows that the three indicators used in measuring mathematical creative thinking ability (MCTA) have increased after being treated with RML assisted by ART and ordinary learning model (OL). For students who received RML assisted by ART, the highest increase in students' MCT ability was achieved in the indicator "Students are able to find original solutions to problems related to flat building material" which amounted to 0.79. While the lowest increase in students' MCT ability was achieved by 0.19, this is included in the low category in the indicator "Students are able to provide varied correct answers from problems related to flat building material". Thus, it is concluded that there is a significant difference in the improvement of MCT ability of students who get RML assisted by ART with students who get OL in terms of high and medium school levels. The difference in ability improvement is due to the difference in treatment applied, the improvement of the two groups seen from the average (N-gain) based on the classification of Meltzer (2002), is included in the medium category.

The above findings can be explained as follows: the implementation of RML assisted by ART, students collaboratively perform mathematical habits of mind to solve problems given by the teacher. These mathematical habits of mind help students build knowledge and at the same time develop MCT skills. Positive attitudes/habits of mathematical thinking such as the above, if it continues, will provide opportunities for the possession of MCT skills and the growth of students' curiosity about mathematics. The attitude or habit of curiosity of students built through RML learning assisted by ART is to identify problem solving steps that can be applied to solve problems on a broader scale and ask themselves if there is "something more" from the mathematical activities that have been carried out. Such an attitude allows students to build knowledge or develop their own MCT skills to solve problems. Balka (Herman, 2016) said that to achieve the indicators of creative thinking ability, at least it can be met with student-centered learning activities, demanding students to construct and reconstruct their knowledge in their own way.

The study also found that there was no interaction between RML assisted ART and school level on the students' attitude scale. On the other hand, students in the experimental class who received RML assisted ART had better curiosity than students who received the OL model. This finding suggests that learning with RML assisted ART is relatively suitable for developing students' overall or both groups of students' MCT skills. In addition, such learning tends to be more suitable for developing students' attitude scale in learning mathematics.

ACKNOWLEDGEMENT

This is a short text to acknowledge the contributions of specific colleagues, institutions, or agencies that aided the efforts of the authors.

REFERENCES

Andrews, C. J. (2022). Preparing to Design Robots for Social Contexts. *IEEE Technology and Society Magazine*, *41*(1), 15–17. https://doi.org/10.1109/MTS.2022.3147530

Borda, E., Schumacher, E., Hanley, D., Geary, E., Warren, S., Ipsen, C., & Stredicke, L. (2020). Initial implementation of active learning strategies in large, lecture STEM courses: Lessons learned from a multi-institutional, interdisciplinary STEM faculty development program. *International Journal of STEM Education*, *7*(1), 4. https://doi.org/10.1186/s40594-020-0203-2

Bush, J. B. (2021). Software-based intervention with digital manipulatives to support student conceptual understandings of fractions. *British Journal of Educational Technology*, *52*(6), 2299–2318. https://doi.org/10.1111/bjet.13139

Chettri, L., & Bera, R. (2020). A Comprehensive Survey on Internet of Things (IoT) Toward 5G Wireless Systems. *IEEE Internet of Things Journal*, *7*(1), 16–32. https://doi.org/10.1109/JIOT.2019.2948888

Davila Delgado, J. M., Oyedele, L., Demian, P., & Beach, T. (2020). A research agenda for augmented and virtual reality in architecture, engineering and construction. *Advanced Engineering Informatics*, *45*, 101122. https://doi.org/10.1016/j.aei.2020.101122

Dewantara, A. H., Setiawati, F. A., & Saraswati, S. (2023). Towards numeracy literacy development: A single-case study on the use of the living book homeschooling model. *Infinity Journal*, *12*(2), 225–242. https://doi.org/10.22460/infinity.v12i2.p225-242

Doolani, S., Wessels, C., Kanal, V., Sevastopoulos, C., Jaiswal, A., Nambiappan, H., & Makedon, F. (2020). A Review of Extended Reality (XR) Technologies for Manufacturing Training. *Technologies*, *8*(4), 77. https://doi.org/10.3390/technologies8040077

ElShishtawy, N., Sinha, P., & Bennell, J. A. (2022). A comparative review of zero-waste fashion design thinking and operational research on cutting and packing optimisation. *International Journal of Fashion Design, Technology and Education*, *15*(2), 187–199. https://doi.org/10.1080/17543266.2021.1990416

Feppon, F., Allaire, G., & Dapogny, C. (2020). Null space gradient flows for constrained optimization with applications to shape optimization. *ESAIM: Control, Optimisation and Calculus of Variations*, *26*, 90. https://doi.org/10.1051/cocv/2020015

Fineldi, R. J., Hidayati, K., & Atmaja, F. L. (2024). *A case study: Analysis of students mathematical creative thinking ability derived from their self efficacy*. 140001. https://doi.org/10.1063/5.0133713

Goyal, K., & Kumar, S. (2021). Financial literacy: A systematic review and bibliometric analysis. *International Journal of Consumer Studies*, *45*(1), 80–105. https://doi.org/10.1111/ijcs.12605

Goyal, M., Gupta, C., & Gupta, V. (2022). A meta-analysis approach to measure the impact of project-based learning outcome with program attainment on student learning using fuzzy inference systems. *Heliyon*, *8*(8), e10248. https://doi.org/10.1016/j.heliyon.2022.e10248

Han, T.-H., Jang, K. Y., Dong, Y., Friend, R. H., Sargent, E. H., & Lee, T.-W. (2022). A roadmap for the commercialization of perovskite light emitters. *Nature Reviews Materials*, *7*(10), 757–777. https://doi.org/10.1038/s41578-022-00459-4

Hilario, L., Mora, M. C., Montés, N., Romero, P. D., & Barquero, S. (2022). Gamification for Maths and Physics in University Degrees through a Transportation Challenge. *Mathematics*, *10*(21), 4112. https://doi.org/10.3390/math10214112

Ibrahim, I., & Widodo, S. A. (2020). ADVOCACY APPROACH WITH OPEN-ENDED PROBLEMS TO MATHEMATICAL CREATIVE THINKING ABILITY. *Infinity Journal*, *9*(1), 93. https://doi.org/10.22460/infinity.v9i1.p93-102

Iwanaga, J., Loukas, M., Dumont, A. S., & Tubbs, R. S. (2021). A review of anatomy education during and after the COVID -19 pandemic: Revisiting traditional and modern methods to achieve future innovation. *Clinical Anatomy*, *34*(1), 108–114. https://doi.org/10.1002/ca.23655

Loureiro, S. M. C., Guerreiro, J., & Ali, F. (2020). 20 years of research on virtual reality and augmented reality in tourism context: A text-mining approach. *Tourism Management*, *77*, 104028. https://doi.org/10.1016/j.tourman.2019.104028

Lu, Y., & Zheng, X. (2020). 6G: A survey on technologies, scenarios, challenges, and the related issues. *Journal of Industrial Information Integration*, *19*, 100158. https://doi.org/10.1016/j.jii.2020.100158

Lungu, A. J., Swinkels, W., Claesen, L., Tu, P., Egger, J., & Chen, X. (2021). A review on the applications of virtual reality, augmented reality and mixed reality in surgical simulation: An extension to different kinds of surgery. *Expert Review of Medical Devices*, *18*(1), 47–62. https://doi.org/10.1080/17434440.2021.1860750

Mahmudah, R., & Yazid, Muh. (2020). Advancing Learning Math Industry Era 4.0. *Journal of Physics: Conference Series*, *1539*(1), 012075. https://doi.org/10.1088/1742-6596/1539/1/012075

Newton, D., Wang, Y. (Linda), & Newton, L. (2022). 'Allowing them to dream': Fostering creativity in mathematics undergraduates. *Journal of Further and Higher Education*, *46*(10), 1334–1346. https://doi.org/10.1080/0309877X.2022.2075719

Oppong-Gyebi, E., Amoako Atta, S., Kwadwo, A.-A., Belbase, S., Bonyah, E., & Peprah Opoku, M. (2023). High School Teachers' Perceptions and Practices of Mathematics Curriculum in Ghana. *Education Research International*, *2023*, 1–11. https://doi.org/10.1155/2023/4304267

Sellali, R., & El Houda Lahiouel, N. (2022). Predicting Algerian Doctoral Students' Academic Burnout Using the Expectancy-Value Model: The Effect of Faculty

Attachment and Years of Enrolment. *International Journal of Doctoral Studies*, *17*, 513–532. https://doi.org/10.28945/5044

Ullah, I., Shen, Y., Su, X., Esposito, C., & Choi, C. (2020). A Localization Based on Unscented Kalman Filter and Particle Filter Localization Algorithms. *IEEE Access*, *8*, 2233–2246. https://doi.org/10.1109/ACCESS.2019.2961740

Vizgin, V. P. & Institute of Philosophy, Russian Academy of Sciences. (2021). Albert Einstein's Epistemic Virtues and Vices. *Epistemology & Philosophy of Science*, *58*(4), 175–195. https://doi.org/10.5840/eps202158468

Zhao, L., Zheng, Y., Mao, H., Zheng, J., Compton, B. J., Fu, G., Heyman, G. D., & Lee, K. (2021). Using environmental nudges to reduce academic cheating in young children. *Developmental Science*, *24*(5), e13108. https://doi.org/10.1111/desc.13108

Zhao, Y., Luh, D., Sun, Y., & Sun, F. (2022). A Design Thinking Technique of Letting Problems Solved by Self. *Mathematical Problems in Engineering*, *2022*, 1–10. https://doi.org/10.1155/2022/3265351