The Mathematics Prospective Teachers Activities when Solving Outdoor Learning Mathematics Projects in the Campus Garden

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Abstract: The facts show that the mathematics achievement of Indonesian students is still very low. One of the causes of this problem is that the learning model used by the teacher is still conventional. This study aims to describe the activities of Mathematics Prospective Teachers (MPT) in completing assignments/projects using the Outdoor Learning Mathematics Project (OLMP). The research subjects were 29 MPT at the Faculty of Teacher Training and Education University of Jember, Indonesia, in August 2022. The type of research was quasi-experimental using one group pretest-posttest design and a one-shot case study. Data were collected using observation sheets, worksheets, learning outcome tests, and questionnaires. Data analysis used descriptive qualitative statistics. From the results of the data analysis, it can be concluded that the OLMP model is effective in increasing the activities of MPT. This can be seen that all groups are very active in carrying out very varied activities during learning activities in the Campus Garden. They can find many mathematical concepts and apply them to complete projects. In addition, with an N-gain score of 0.79, the OLMP model is effective in improving the learning outcomes of MPT. The majority of the subjects (97.59%) have a very positive response concerning the application of the OLMP teaching model. In the future, further research needs to be carried out using more subjects from various fields of science, and in many places. It is hoped that MPT can be skilled in guiding students using the OLMP model when they are already teachers at school.

Keywords: Learning Activities, Learning outcomes, Mathematics Project, Outdoor Learning, Students' Response.

INTRODUCTION

The Mathematics Prospective Teachers (MPT) need to be guided in mastering skills using various innovative learning models. This is necessary so that when they become mathematics teachers in schools, they can use this innovative model in the mathematics learning process to improve students' mathematics achievement. Because the facts show that until now the mathematics learning achievement of Indonesian students is still very low. For example, the results of the PISA tests of fifth-grade elementary and 8 junior high school students in Indonesia for mathematics are still very low. The ranking of Indonesian students in 2012 was 64 out of 65 participating countries (OECD, 2014), in 2015, ranking 62 out of 70 countries (OECD, 2016), and in 2018 ranking 73 out of 79 countries (OECD, 2019).

The low mathematics achievement of students is caused by many teachers still using conventional learning models. The characteristic of conventional learning is that it is mechanistic which is oriented to the completeness of the material and is only carried out in the classroom. As a result, this kind of learning is less meaningful, less interesting, and boring for students and low learning achievement (Fauzia, et al., 2020; Fonseca, et al., 2020; Pambudi, 2022; Yeh, et al., 2019). Reflecting on these problems, the conventional model should immediately be replaced with an innovative learning model. Therefore, MoECRT RI (2022) recommends the use of a project-based learning model (PjBL) in schools.

So far, MPT only attend lectures in the classroom, so they need to be guided to attend lectures outside the classroom, for example in campus gardens. For learning activities using the OLM method in campus gardens to be effective, it needs to be integrated with the PjBL model, which we named the OLMP (Outdoor Learning Mathematics Project) model (Pambudi, et al., 2022). This means that MPT are allowed to carry out various activities to find mathematical concepts and complete tasks/projects related to the campus garden. There are several interesting things to study regarding the application of the OLMP model to MPT in campus gardens. The questions posed in this study are as follows:

1. How is the activity of MPT in learning mathematics using the OLMP model?
2. What mathematical concepts are found in mathematics learning activities using the OLMP model?
3. Is the OLMP model effective in improving the learning outcomes of MPT?
4. What is the response of MPT after doing the activity of finding mathematical concepts using the OLMP model?

The purpose of this study is to describe the activity, mathematical concepts, learning outcomes, and the response of MPT when they doing the activity of finding mathematical concepts using the OLMP model.

LITERATURE REVIEW

Project Based Learning (PjBL)

PjBL is a learning model that guides students to complete assignments/projects in groups. PjBL can be applied to various subjects to guide students to achieve abilities, such as collaborating, thinking creatively, critically, and communicatively, and improving student learning outcomes (Irham, et al., 2022; Kay, & Greenhill, 2011; Williams, & Charless-Ogan, 2016). The PjBL syntax is as follows: (1) The teacher selects a subject, topic, and context, (2) The teacher designs a project from the selected topic, (3) The teacher determines the project completion time, (4) The teacher motivates, and monitors project completion, (5) Report generation and group presentations, (6) Assessment: learning activities, attitudes, skills, and learning outcome tests, and (7) Reflection and follow-up (Wolpert-Gawron, 2016; Viro, et al., 2020; Haatainen, & Aksela, 2021; Markula, & Aksela, 2022; MoECRT RI, 2022).

Outdoor Learning in Mathematics (OLM)

In learning mathematics, the teacher not only guides students to learn abstract concepts in the classroom, but the teacher can complement it by using the Outdoor Learning method (Richmond, et al., 2017). Outdoor Learning in Mathematics (OLM) is the right method to guide students in learning mathematics by doing mathematics, namely finding concepts and applying them to solve problems outside the classroom. This method is widely applied in various countries, such as in Chile (Vásquez et al., 2020), Europe (Bearnes & Ross, 2010; Bilton, 2014; Fägerstam, & Blom, 2012; Waite, 2011; Zotes & Arnal-Palacián ,2022), USA (Feille, 2021; Moss, 2009), Australia (Laird, et al., 2021; Thomas, 2018); and Malaysia (Mohamed, et al., 2021; Samsudin, et al., 2021). OLM succeeded in increasing student motivation, students' learning outcomes (Cahyono, et al., 2020; Fägerstam, & Blom, 2012; Laird, et al., 2021; Pambudi, 2022; Widada, et al., 2019), and improving students' connections (Ernawati, & Amidi, 2022; Haji, et al., 2017; Pambudi, et al., 2022). Unfortunately, this method is still rarely used by mathematics teachers in Indonesia (Haji, et al., 2017; Pambudi, 2022; Widada, et al., 2019).

METHOD

Research Subject, Place, and Time

The research subjects were students of MPT, FKIP University of Jember (Unej) semester 3 from class C as many as 29 people (6 Male and 23 Female). Data collection was carried out in the campus garden on August 2022.

Research Types and Approach

The type of research is quasi-experimental using a one-group pretest-posttest design combined with a one-shot case study design (Arikunto, 2013; Creswell, 2014; Sugiyono, 2015; Pambudi, et al., 2022). The approach used is descriptive qualitative, to describe activities, findings of mathematical concepts, and responses to MPT in learning using the OLMP model.

Method of Data Collection

The research data consists of (1) research subject activities during the learning process using the OLMP model; (2) mathematical concepts found from activities using the OLMP model; (3) the subjects' responses to the application of the OLMP teaching model; (4) subjects' learning outcomes. The data collection methods used were observation, test, and questionnaire.

The instruments used are: (1) an observation sheet to observe the activities of research subjects, (2) a Students' Worksheet (SW) to record mathematical concepts found during learning, (3) the subject's response questionnaire to the OLMP model contains 10 questions according to the Likert scale, and (4) The written test contained 3 questions (Geometry, Trigonometry, and Differential Calculus) to determine the subject's learning outcomes. All of these instruments have been validated by 3 mathematics education experts, and are declared valid, with a score between 4.3 to 4.7 (scores ranging from invalid 0 to a maximum score of very valid 5.0). The Cronbach's Alpha are declared reliables, with a score between 0.75 to 0.85 (scores ranging from not reliable 0 to a maximum score of very reliable 1.0).

Through the OLMP model, students are given the task of observing, and designing projects related to mathematics in the campus garden of FKIP Unej. There are 3 projects agreed to be done by MPT.

Figure 1: Campus Garden

Project 1: measuring the perimeter and area of the campus garden (Figure 1).

a) Make a sketch, and measure the perimeter and area of the campus garden.
b) What is the area of the campus garden that does not include the road, Gazebo, and fountain pool in the middle of the garden?

Figure 2: Fountain Pool

Project 2: Calculating the speed related to the filling of water in the fountain pool (Figure 2). When water is put into the pool with a tap water hose at a uniform rate of 2 liters per minute. How fast is the water surface rising when the water depth is 20 cm?

Figure 3: Flagpole

Project 3: measuring the height of the flagpole (Figure 3).

a) Observe, sketch, and measure the height of the flagpole using the concept of Trigonometry.
b) Think of other ways to measure the height of the flagpole.

METHOD

The data from the observation of learning activities and mathematical concepts found by the subject during learning using the OLMP model were analyzed descriptively and qualitatively. The research subject's response questionnaire to the OLMP model consisted of 10 positive statements with answer choices of SA (Strongly Agree), A (Agree), N (Neutral), D (Disagree), and SD (Strongly Disagree). Score for answer choices SA = 5, A = 4, N = 3, D = 2, and SD = 1. A goodness-of-fit test of one-sample Kolmogorov-Smirnov test was employed to determine the uniformity of data by following the level of significance is 5%, using SPSS software version 21.

Students learning outcome test results were analyzed using an effectiveness test (N-gain score) on pre-test and post-test data (Hake, 1999; Sundayana, 2015), with the formula as follows.

$$N - gain\ score = \frac{posttest\ value - pretest\ value}{ideal\ value - pretest\ value}$$

The categories N-gain score (g) can be seen in Table 1.

N-Gain Score (g)	Category
$-1.00 < g < 0.00$	Occur drop
$g = 0.00$	Permanent
$0.00 < g < 0.30$	Low
$0.30 < g < 0.70$	Moderate
$0.70 < g < 1.00$	High

Table 1: Criteria for N-Gain Score (g)

RESULTS

The MPT Activities in Solving Projects in the Campus Garden

The MPT activities while working on projects vary widely, both physically and mentally. There is a member who holds the end of the roll meter, and another member pulls the roll meter to the end of the measurement. Other members record the data obtained at the SW. Other members observe and advise on the accuracy of measurements. Then they sat on a garden bench to sketch the campus garden, discuss the results of their work group, and complete the SW. Some MPT activities can be seen in Figure 4.

Figure 4: MPT Activities in Solving Mathematics Projects in the Campus Garden

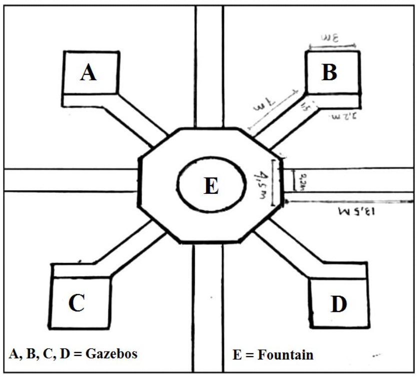


Figure 5: A sketch of FKIP Unej's campus garden

In the second project, after the MPT collected data directly on the radius ($r=1.25$ m), pool height (h *meters*), and pool volume ($V=\pi r^2 h$). After that, they used the concept of derivative and related rate ($dV/dt=2$ *liters/minute*), to calculate the rate of increase in water (dh/dt) which was introduced into the pond at a time h = *20 centimeters*. After performing arithmetic operations on real numbers, MPT get the answer $dh/dt=0.0004$ *liters/minute.*

The third project is to measure the height of the flagpole using the concept of Trigonometry, and other ways. Here, all group members collaborated to carry out various activities, such as the first member who served as an observer observing the top of the flagpole with a clinometer. The second member measured the height of the observer and the distance of the observer to the flagpole. The third and forth members made a sketch and wrote the results of the experiment in SW. From the right triangles obtained on the flagpole, and the flag hoist, the group can find the formulas for Sine, Cosine, and Tangent on the sides of the right triangle. Next, they calculated the height of the flagpole using the tangent formula. Because the angle of the clinometer is 37^o, then the angle of elevation between the line from the top to the horizontal is $90-37^o=53^o$. By substituting the elevation angle data, the observer's distance to the flagpole ($b=7$ *meters*), and the observer's height of 1.6 meters, the flagpole height is close to 11 meters.

After all groups have completed the project, the lecturer asks a lighter question "Do you think there are other ways to calculate the height of the flagpole?" This question is directed to guide the MPT to think creatively and connect various mathematical concepts. Some of them answered the question in three other ways. The first method uses the concept of an isosceles right triangle (this concept was learned in elementary school). The concepts connected are the definition of an isosceles right triangle, the properties of an isosceles right triangle, right angles, elevation angles, and flagpole heights. By forming a right angle between the flagpole and the horizontal rope at the base of the flagpole and an elevation angle of 45^o, the height of the flagpole is equal to the distance from the flagpole to the observer. The second method uses similarity triangles (this concept was learned in junior high school). The concept that is connected is the concept of the similarity of triangles to the height of the flagpole. The third method uses the length of the shadow of an object due to sunlight (this concept was learned when studying science in junior high school).

Recapitulation of Mathematical Concept Findings by MPT

Next, from the results of working on 3 projects, MPT wrote down the findings of mathematical concepts in SW. The concepts they found are presented in Table 2.

No.	Projects/Topics/Courses	Concept Finding
1.	**Project 1**: the context of measuring the perimeter and area of the garden /**Topic/Course**: Geometry	Area and perimeter of rectangle (whole garden.; Square area (gazebo base); Area of a regular octagon (the base around the fountain); Radius, diameter, and circle on the fountain pool; Fountain pool height; Fountain pool volume, and Real number operations.
2.	**Project 2**: the context of related rate **Topic/Course**: Differential Calculus	Fountain pool volume; Derivative.; Related rate; Real number operations.
3.	**Project 3**: context measuring the height of the flagpole. **Topic/Course**: Trigonometry and related subjects	Rectangular; Right triangle; Pythagorean Theorem; Elevation angle; Sines, Cosines, Tangen; Comparison; Similarity of triangle; Length of the object's shadow due to sunlight; Real number operations.

Table 2: Mathematical Concepts Found

From collaborative activities, the MPT were able to rediscover many mathematical concepts to complete 3 projects on the topics of Geometry, Differential Calculus, and Trigonometry. On the topic of Geometry, they found the concept of a square, from the shape of a garden, then the area and perimeter of a square, the area, and perimeter of a rectangle, a circle, the area of a regular octagon, and the volume of a tubular fountain. On the topic of Trigonometry, they can develop creativity to calculate the height of the flagpole. Here, they can use the concepts of trigonometry, the similarity of triangles, isosceles right triangles, and use the length of the flagpole's shadow due to sunlight.

The MPT Learning Outcomes

Before the implementation of learning using the OLMP model, the MPT were given a Pre-Test, and after that, they were given a Post-Test. The results of the Pre-Test and Post Test can be seen in Table 3.

No.	Pre-test (n=29)				Post-test (n=29)			
	Geo	Cal	Tri	Average	Geo	Cal	Tri	Average
Maximum Score	80.00	70.00	100.00	78.33	100.00	100.00	100.00	100.00
Minimum Score	70.00	40.00	90.00	65.00	90.00	80.00	90.00	88.33
Average	77.24	50,17	93.28	73.56	97.24	87.59	98.79	94.54
St Deviation	3.43	6.19	4.28	3.20	3.68	6.76	2.55	3.05

Table 3: Pre-Test and Post-Test Results

From Table 3, it can be seen that the average Pre-Test score of 73.56 increased to 94.54 from the Post Test results. From this increase, if the N-gain score is calculated, the results are (94.54-73.56)/(100-73.56) = 20.98/26.44 = 0.79, which means that the OLMP model is effective (high category) in improving the learning outcomes of the MPT. An example of a MPT's work for a GEO (Geometry) problem is as follows.

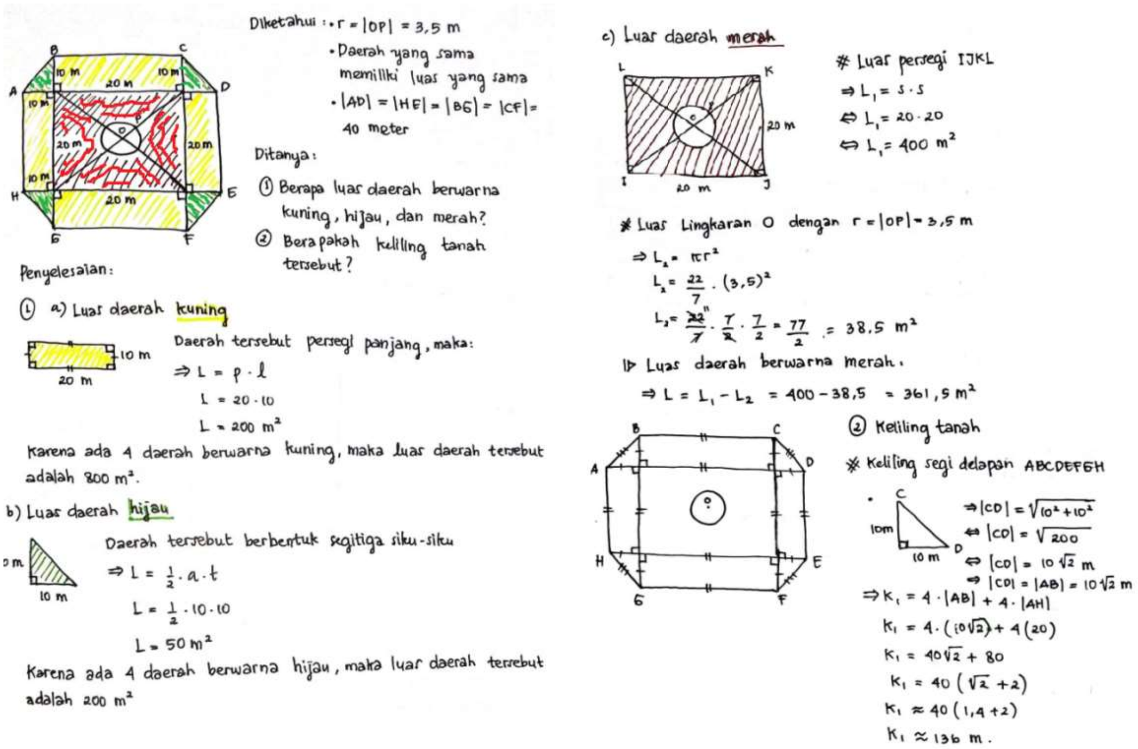
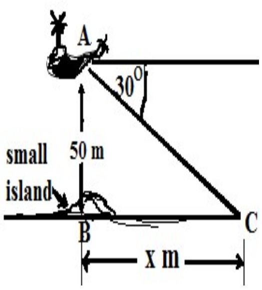


Figure 6: Test results on Geometry post-test questions

The post-test questions for Trigonometry can be seen in Figure 7. An example of an answer from a MPT can be seen in the same figure.



A helicopter pilot at an altitude of 50 meters looks directly at a small island (B) in the Bali strait. From the helicopter, the pilot also saw a place opposite the small island, namely, point C. If the angle of depression is 30°, what is the distance of the islet to point C?

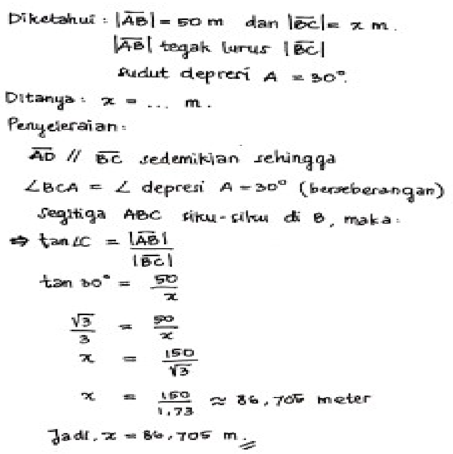


Figure 7: Post-test question and answer for Trigonometry

From their activity in working on projects in the campus garden, they found many mathematical concepts related to Geometry, Differential Calculus, and Trigonometry. This certainly encourages them to study harder to face the post-test. This high learning motivation is able to lead them to achieve optimal achievement in the post-test.

The MPT's response about the OLMP model

The MPT's response to the OLMP model was obtained from the results of filling out the questionnaire. To find out the subject's response to the OLMP model, a test was carried out using the Kolmogorov-Smirnov test. The test results for the 10 statements SA and A can be seen in Table 4.

From Table 4, it was concluded that 97.59% of the respondents agree and strongly agree with the application of the OLMP teaching model in the mathematics learning process. This means that the majority of the MPT have a very positive response concerning the application of the OLMP teaching model. MPT argue that the OLMP model has more benefits than the conventional model.

No.	Statements of Questionnaire	SA and A Chosen (%)	Kolmogorov Smirnov
1.	The OLMP model makes MPT more physically and mentally active in the mathematics learning process compared to conventional models	100.00	3.343
2.	The OLMP model makes MPT can improve collaborative, creative, and communicative abilities	100.00	3.157
3.	The OLMP model makes mathematics learning more meaningful than the conventional model	100.00	3,528
4.	The OLMP model makes mathematics learning more unforgettable compared to conventional models	100.00	3.343
5.	The OLMP model makes the learning atmosphere more relaxed, fun, and not boring compared to the conventional model	100.00	2,785
6.	Using the OLMP model, MPT can be taught the importance of environmental care attitudes	100.00	3.157
7.	The campus garden is always a comfortable, beautiful, and healthy place to study	100.00	2,971
8.	Learning mathematics in the campus garden can make prospective teachers have a positive attitude towards mathematics	100.00	3.343
9.	The OLMP model makes MPT a high motivation to learn mathematics compared to conventional models	100.00	3.157
10.	The OLMP model can make MPT achieve optimal learning outcomes compared to conventional models	75.86	1.857
	Average	97.59	

Table 4: Kolmogorov Smirnov test of Strongly Agree (SA) and Agree (A) on MPT's responses about the OLMP model

DISCUSSION AND CONCLUSIONS

From the above explanations, we can discuss about several interesting results. Firstly, the use of the OLMP model can increase the activity of the MPT in learning mathematics. This can be seen from the observation data that all groups (100%) are very active in carrying out very varied activities during learning activities. They do more activities when studying outside the classroom than when studying in the classroom. Secondly, the use of the OLMP model can improve MPT activities, and collaboration skills. This can be seen from all groups planning, and carrying out activities to complete projects together. These results are followed by the results of research by Laird, et al. (2021); Mygind, (2007); and Pambudi, et al. (2022). It is clear that the campus garden is effectively a place for MPT to improve collaborative skills and creativity in finding many mathematical concepts and applying them to complete projects given by lecturers. These results are followed by the opinion of Agusta, & Noorhapizah (2018); Auliadari, et al. (2019); Usmeldi, & Amini (2022); and Pambudi, et al. (2022). Thirdly, the use of the OLMP model can improve MPT learning outcome. These results are are followed by the opinion of Auliandari, et al. (2019); Fägerstam, & Bloom (2012); Fonseca, et al. (2020); Laird, et al. (2021); and Pambudi, et al. (2022). Thus, the OLMP model can improve activities, collaborative, creative, and communicative abilities. This strongly supports learning oriented toward improving life skills in the 21st century (Wijaya, et al., 2019; Irham, et al., 2022; Kay, & Greenhill, 2011; Mabitad, et al., 2021; Usmeldi, & Amini, 2022).

In addition, the OLMP model makes mathematics learning more meaningful and unforgettable. Because, using the OLMP model, the MPT can also be taught the importance of environmental care attitudes, such as maintaining cleanliness in campus gardens, and not littering, so that the garden is always a comfortable, beautiful, and healthy place to study. This is followed by the opinion of Agusta, & Noorhapizah (2018); Mann, et al. (2022); and Pambudi (2022). A comfortable and pleasant learning atmosphere in campus gardens has made the MPT have a positive attitude toward mathematics so motivation increases (Cameron, & McGue, 2019; Mackenzie, et al., 2018; Ryan, et. al, 2010). The more MPT learn, both independently and in groups, the more mathematical concepts are found and understood by them. Mastery of mathematical concepts and sufficient learning experience make the MPT succeed in taking the learning outcome test with optimal results. So, the OLMP model can improve student learning outcomes. These results are followed by the opinion of Auliandari, et al. (2019); Fägerstam, & Bloom (2012); Fonseca, et al. (2020); Laird, et al. (2021); and Pambudi, et al. (2022). However, some subjects argued that mathematics learning achievement was not only influenced by the learning model, but could be caused by the level of difficulty of the questions and others.

From the results of data analysis, it can be concluded that the OLMP model is effective in increasing activities of the mathematics teacher candidates (MPT). This can be seen that all groups are very active in carrying out very varied activities during learning activities. They can find many mathematical concepts and applying them to complete projects. In addition, with an N-gain score of 0.79, the OLMP model is effective improving the learning outcomes of MPT. The majority of the subjects (97.59%) have a very positive response concerning the application of the OLMP teaching model. MPT argues that the OLMP model has more benefits than the conventional model.

The limitation of the research is that the research subject only uses 1 class of mathematics education students. In the future, it is necessary to carry out further research in mathematics, science, technology, and engineering students so that they become STEM Outdoor Learning Projects. Research places also need to be expanded, and set up in various forms, such as math trails, field trips, camps, and others.

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References

[1] Adamma, O. N. (2018). Influence of Extrinsic and Intrinsic Motivation on Pupils Academic Performance in Mathematics. *Supremum Journal of Mathematics Education, 2*(2), 52–59.

[2] Agusta, A. R., & Noorhapizah. (2018). Improving the Students' Cooperation and Environmental Care Skill using Outdoor Learning Strategy Outbound Variation. 1st International Conference on Creativity, Innovation, Technology in Education (IC-CITE 2018). Atlantis Press. https://doi.org/10.2991/iccite.18.2018.3

[3] Auliandari, L., Agusta, E., & Bintari, S. E. (2019). Does problem-based learning through outdoor learning enhance creative thinking skills? Jurnal Bioedukatika, 7(2), 85-96. https://doi.org/10.26555/bioedukatika.v7i2.11708

[4] Bearnes, S. & Ross, H. (2010). Journeys Outside the Classroom. Journal of Adventure and Outdoor Learning, 10(2), 95-109. https://doi.org/10.1080/14729679.2010.505708

[5] Bilton, H. (2014). The Aims of Early Years Outdoor Education in England : A Conceptual and Empirical Investigation. International Journal of Education and Social Science, 1(3), 38-50. https://centaur.reading.ac.uk/39923

[6] Cahyono, A. N., Sukestiyarno, Y. L., Asikin, M., Miftahudin, Ahsan, M. G. K., & Ludwig, M. (2020). Learning Mathematics Modelling with Augmented Reality Mobile Math Trails Program: How Can It Work?. Journal on Mathematics, Education, 11(2), 181-192. https://doi.org/10.22342/jme.11.2.10729.181-192

[7] Cameron, M., & McGue, S. (2019). Behavioral Effects of Outdoor Learning on Primary Students. https://sophia.stkate.edu/maed/297

[8] Damrongpanit. (2019). From Modern Teaching to Mathematics Achievement: The Mediating Role of Mathematics Attitude, Achievement Motivation, and Self-Efficacy, European Journal of Educational Research. 8(3), 713–727. https://doi.org/10.12973/eu-jer.8.3.713

[9] Ernawati, & Amidi. (2022). Kajian Teori: Pengembangan Bahan Ajar Berbasis Outdoor Learning dengan Model Connected Mathematics Project (MCP) dan Pendekatan Saintifik untuk

Meningkatkan Kemampuan Koneksi Matematis. PRISMA, Proseding Seminar Nasional Matematika, 5, 559-564. https://journal.unnes.ac.id/sju/index.php/prisma/article/view/54691/21118

[10] Fägerstam, E. & Blom, J. (2012). Learning Biology and Mathematics Outdoors: Effects and Attitudes in a Swedish High School Context, Journal of Adventure & Outdoor Learning,1-20. https://dx.doi.org/10.1080/14729679.2011.647432

[11] Feille, K. (2021). A Framework for the Development of Schoolyard Pedagogy. Research in Science Education , 51(8). https://dx.doi.org/10.1007/s11165-019-9860-x

[12] Fonseca, L. F., Cacais, J., & Fernandes, C. (2020). Learning mathematics outside the classroom: experiences in primary school. CIEAEM 71_Proceedings_"Quaderni di Ricerca in Didattica (Mathematics)", Numero speciale n. 7, 2020, pp. 105-113. https://www.researchgate.net/publication/343794256_Learning_mathematics_outside_the_classroom_experiences_in_primary_school/link/5f3fdd9292851cd30210a353/download

[13] Haji, S., Abdullah, M.I., Maizora, S., Yumiati (2017). Developing Students' Ability of Mathematical Connection Through Using Outdoor Mathematics Learning. Infinity Journal of Mathematics Education, 6(1), 11-20. https://doi.org/10.22460/infinity.v6i1.234

[14] Hake, R.R. (1999). Analyzing Change/ Gain Scores. Woodland Hills: Dept. of Physics, Indiana University

[15] Hanif, S., Wijaya, A. F. C., & Winarno, N. (2019). Enhancing Students' Creativity through STEM Project-Based Learning. Journal of Science Learning, 2(2), 50. https://dx.doi.org/10.17509/jsl.v2i2.13271

[16] Harun, M.T., & Salamuddin, N. (2014). Promoting Social Skills through Outdoor Education and Assessing Its' Effects. Asian Social Science, 10(5), 71-78. https://dx.doi.org/10.5539/ass.v10n5p71

[17] Hossain, M.A., Tarmizi, R.A., & Ayub, A.F.M. (2012). Collaborative and Cooperative Learning in Malaysian Mathematics Education. Journal on Mathematics Education 3(2), 102-114. https://ejournal.unsri.ac.id/index.php/jme/article/view/569

[18] Irham, Tolla, I., Jabu, B. (2022). Development of the 4C Teaching Model to Improve Students' Mathematical Critical Thinking Skills. International Journal of Educational Methodology, 8(3), 493-504. https://doi.org/10.12973/ijem.8.3.493

[19] Kay, K., & Greenhill, V. (2011). Twenty-First Century Students Need 21 Century Skills. In Wan, G., & Gut, D.M. (Eds). Bringing Schools into 21st Century. London: Springer, 41-46.

[20] Laal, M., & Ghodsi, S.M. (2012). Benefits of Collaborative Learning. Procedia Social and Behavioral Sciences, 31(2012), 486-490. https://doi.org/10.1016/j.sbspro.2011.12.091

[21] Laird, A., Grootenboer, P., & Larkin, K. (2021). Engagement and outdoor learning in mathematics. In Y. H. Leong, B. Kaur. H. Choy, J. B. W. Yeo, & S. L. Chin (Eds). Excellen in Mathematics Education: Foundations and Pathways (Proceedings of the 43rd annual conference of the Mathematics Education Research Group of Australasia), pp. 265-272. Singapore: MERGA. https://files.eric.ed.gov/fulltext/ED616162.pdf

[22] Mabitad, B., Rebuyas, R. S., Ngoho, J. C., Basmayor, J. G. (2021). The 4c's Century Skills In Teaching And Learning Trigonometry. Turkish Online Journal of Qualitative Inquiry (TOJQI), 12(6), 5563-5571. https://www.tojqi.net/index.php/journal/article/view/2371/1529

[23] Mackenzie, S. H., Son, J. S., & Eitel, K. (2018). Using outdoor adventure to enhance intrinsic motivation and engagement in science and physical activity: An exploratory study. Journal of Outdoor Recreation and Tourism, 21, 76-86. https://doi.org/10.1016/j.jort-2018.01.008

[24] Markula, A., & Aksela, M. (2022). The Key Characteristics of Project Based Learning: How Teachers Implement Projects in K-12 Science Education. Disciplinary and Inter Disciplinary Science Education Research, 4(1): 1-17. https://doi.org/10.1186/s43031-021-00042-x

[25] MoECRT RI (2022). Kurikulum Prototipe Utamakan Pembelajaran Berbasis Proyek. [Prototipe Curriculum Promote Learning Based Projects. https://ditpsd.kemdikbud.go.id/artikel/detail/kurikulum-prototipe-utamakan-pembelajaran-berbasis-proyek

[26] Mohamed, M., Alpandi, S. N., Kamal, A. A., et. al. (2021). Outdoor Education in Promoting Nature Appreciation: A Survey through Activity Enjoyment among PhysicalEducation students in a Public University. ACPES Journal of Physical Education, Sport, and Health, 1(1), 87-95. https://doi.org/10.15294/ajpesh.v1i1.46326

[27] Moss, M. (2009). Outdoor Mathematical Experiences: Constructivism, Connections, and Health. In: Clarke B; Grevholm B; Millman R. (eds) Tasks in Primary Mathematics Teacher Education. Springer, Boston, MA. Mathematics Teacher Education, 4(1):263-273. https://doi.org/10.1007/978-0-387-09669-8_17

[28] Mygind, E. (2007). A Comparison between children's physical activity levels at school and learning in an outdoor environment. Journal of Adventure and Outdoor Learning, 7(2):161-176. https://doi.org/10.1080/14729670701717580

[29] National Council of Teachers of Mathematics. (2014). Principles to action: Ensuring mathematical success for all. Reston, VA: NCTM

[30] OECD. (2014). PISA 2012 Results in Focus: What 15-year-old know and what they can do with what they know. Paris: OECD.

[31] OECD. (2016). PISA 2015 Result (Vol. 1): Excellence and Equity in Education. Paris: OECD.

[32] OECD. (2019). PISA 2018 Results. https://www.oecd.org/pisa/publications/pisa-2018-results.html

[33] Pambudi, D. S. (2022). The Effect of Outdoor Learning Method on Elementary Students' Motivation and Achievement in Geometry. International Journal of Instruction, 15(1), 747-764. https://doi.org/10.29333/iji.2022.15143a

[34] Pambudi, D. S., Sunardi, & Sugiarti, T. (2022). Learning Mathematics Using a Collaborative RME Approach Indoor and Outdoor the Classroom to Improve Students' Mathematical Connections Ability. Jurnal Pendidikan Matematika, 16 (3), 303-324. https://doi.org/10.22342/jpm.16.3.17883.303-324

[35] Richmond, D., Sibthorp, J., Gookin, J., Annarella, S., & Ferri, S. (2017). Complementing classroom learning through outdoor adventure education : out-of-school-time experiences that make a difference. Journal of Adventure Education and Outdoor Learning, 1–17. https://doi.org/10.1080/14729679.2017.1324313

[36] Ryan, Richard, Weinstein, N., Bernstein, J., Brown, K., Mistretta, L., & Gagne, M. (2010). Vitalizing effects of being outdoors and in nature. Journal of Environmental Psychologym 30(2), 159-168. https://doi.org/10.1016/j.jenvp.2009.10.009

[37] Samsudin, S., Kamalden, T. F. T., Aziz, A., Ismail, M. H., Yaakob, S. S. N., & Farizan, N. H. (2021). The Impact of Outdoor Education Camp Program in Building Resilience among University Students. Asian Journal of University Education. 17(4), 71-83. https://doi.org/10.24191/ajue.v17i4.16185

[38] Smarter Scotland Scottish Goverment (2010). Curriculum for excellence through outdoor learning. SSSG Scotland. Retrived from. https://education.gov.scot/documents/cfe-through-outdoor-learning.pdf

[39] Sumardi, L., Rohman, A., & Wahyudiati, D. (2020). Does the Teaching and Learning Process in Primary Schools Correspond to the Characteristics of the 21st Century Learning? International Journal of Instruction, 13(3), 357-370. https://doi.org/10.29333/iji.2020.13325a

[40] Sundayana. 2015. Statistics for Educational Research [in Bahasa]. Bandung: Alfabeta.

[41] Thomas, G. J. (2018). Effective Teaching and Learning Strategies in Outdoor Education, findings from two residential programmes based in Australia. Journal of Adventure and Outdoor Learning, 19(3):1-14. https://doi.org/10.1080/14729679.2018.1519450

[42] Usmeldi, & Amini, R. (2022). Creative project-based learning model to increase creativity of vocational high school students. International Journal of Evaluation and Research in Education (IJERE), 11(4), 2155-2164. https://doi.org/10.11591/ijere.v11i4.21214

[43] Varberg, D., Purcell, E. J., & Rigdon, S. E. (2013). Calculus : Pearson New International Edition (9th ed.). Pearson Education.

[44] Vásquez, C., Seckel, M. J., & Alsina, Á. (2020). Sistema de creencias de los futuros maestros sobre Educación para el Desarrollo Sostenible en la clase de matemática. Revista Uniciencia, 34(2), 16-30.

[45] Viro, E., Lehtonen, D., Joutsenlahti, J., & Tahvanainen, V. (2020). Teachers' Perspectives on Project Based Learning in Mathematics and Science. European Journal of Science and Mathematics Education, 8(1): 12-31. https://doi.org/10.30935/scimath/9544

[46] Waite, S. (2011). Teaching and Learning Outside the Classroom: Personal Values, alternative Pedagogies, and Standards. Education 3-13, 39(1):65-82. https://doi.org/10.1080/03004270903206141

[47] Waite, S. & Pleasants. (2012). Cultural Perspectives on Experiential Learning in Outdoor Spaces. Journal of Adventure and Outdoor Learning, 12(3):161-165. https://doi.org/10.1080/14729679.2012.699797

[48] Widada, W., Herawaty, D., Anggoro, A. F. D., Yudha, A., & Hayati, M. K. (2019). Ethnomathematics and Outdoor Learning to Improve Problem Solving Ability. Proceedings of the International Conference on Educational Sciences and Teacher Profession (ICETEP) 2018, Atlantis Press. https://doi.org/10.2991/icetep-18.2019.4

[49] Williams, C., & Charless-Ogan, G. (2016). Integrating the 4C's in the Learning of Science and Mathematics. International Journal of Mathematics and Technology, 35(1), 38-49. https://ijmttjournal.org/2016/Volume-35/number-1/IJMTT-V35P506.pdf

[50] Wolpert-Gawron, H. (2016). DIY Project Based Learning for Math and Science, 1st ed. Routledge Taylor & Francis Group. https://doi.org/10.4324/9781315709598

[51] Yeh, C. Y. C., Cheng, H. N. H., Chen, Z. H. et al. (2019). Enhancing achievement and interest in mathematics learning through Math-Island. Research and Practice in Technology Enhanced Learning, 14(5), 1-19. https://doi.org/10.1186/s41039-019-0100-9

[52] Zotes, E., & Arnal-Palacián, M. (2022). Matemáticas en Educación Infantil: una mirada al aprendizaje de las magnitudes desde el desarrollo sostenible. Educación matemática, 34(1), 306-334.