



Implementation of STEAM-based learning to increase motivation to learn mathematics in Grade IV SDN 13 Langsa

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ABSTRACT

This research emerged on the basis of problems in learning mathematics has not emphasized the indicators of student learning motivation. The effort to overcome these problems with innovative learning is STEAM-based learning. This study aims to analyze the application of Science, Technology, Engineering, Art and Mathematic (STEAM) based learning to increase motivation to learn mathematics on the material of the nets of blocks and cubes in class IV SDN 13 Langsa. The method in this study used Classroom Action Research (PTK) involving 28 students. The research method steps starting from the planning, implementation, observation and reflection stages. Data collection methods include questionnaires of students' math learning motivation, observation and documentation. Qualitative and quantitative data analysis was used to measure the success of math learning motivation and the quality of the learning process. The results showed that math learning motivation increased after the application of STEAM-based learning. In the pre-cycle, the value of math learning motivation obtained an average of 2.64 with student learning success of 18%. In cycle I, the value of math learning motivation obtained an average of 3.14 with student learning success of 68%. In cycle II, the value of mathematics learning motivation obtained an average of 3.84 with student learning success of 100%. Recommendations are the need to strengthen teacher creativity, develop learning innovations and improve student abilities to improve the overall quality of learning.

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INTRODUCTION

Mathematics is defined as a science that is used in human life. Mathematics has an important role factor in the development of technology, other disciplines and the development of human thinking. Therefore, mathematics is a subject that must be taught at all levels of education in schools, including the elementary school level. Mathematics learning in elementary schools aims to equip students with various mathematical abilities such as problem solving, reasoning, communication, connection and representation. It aims to train students to think critically, logically, creatively, analytically, systematically and creatively so that they can generate ideas or

solutions in solving problems in everyday life (Lestari, 2021; Kamarullah, 2017; Maulyda, 2020; NCTM, 2000; Anggraini, 2021; Gusteti & Neviyarni, 2022).

In achieving the goals of learning mathematics at school, an educator must be able to make students interested and have more curiosity in learning mathematical materials. Educators are required to create creative and innovative mathematics learning and be able to develop 21st century skills so that all the potential and mathematical abilities of students can develop optimally. Quality mathematics learning can facilitate students' needs, interests, enjoyment, the times and materials that are close to everyday life. Such a learning process will have an impact on the variables that influence student learning success factors (Intan et al., 2022; Ismail, 2018; Isnawan & Wicaksono, 2018; Szabo et al., 2020; Tabuena & Pentang, 2021; Hendriani et al., 2023).

In the learning process, the role of the teacher is very central in supporting the success of student learning. Teachers who provide education and motivate during learning activities. The positive attitude created by the teacher produces a positive direction for students to learn mathematics. In this study, there is more emphasis on student learning motivation. In a math class, motivation refers to the activity of students in learning mathematical knowledge (Raj Acharya, 2017; Husna et al., 2021; Farhan et al., 2022; Munthe & Pasaribu, 2023).

Learning motivation is one of the factors that contribute to learning. Students with good learning motivation will be more enthusiastic and not easily discouraged in learning so that it leads to success in their academic achievement. Students' motivation to learn mathematics refers to the following aspects: (1) Persevere in facing tasks; (2) Tenacious in the face of adversity; (3) Showing interest; (4) Enjoy working independently; and (5) Can defend their opinions (El-Adl & Alkharusi, 2020; Vankúš, 2021; Filgona et al., 2020; Vu et al., 2022; Hallifax et al., 2020; Hallifax et al., 2020; Nasrah & Muafiah, 2020; Sudibyo et al., 2016).

However, based on the results of a preliminary study conducted at SDN 13 Langsa, problems were found: *First*, the results of interviews with students about motivation to learn mathematics found that students stated that the math material explained by the teacher was difficult to understand. Students are not confident in solving math problems and there are still many students who cheat on their friends' work. Students think that learning math is difficult and not fun. Students are lazy to participate in learning because the activities carried out are only memorizing, recording formulas, and answering practice questions. Students' responses are very negative to the math learning that their teachers have done so far.

Second, the results of the initial questionnaire on students' mathematics learning motivation on the material of the nets of blocks and cubes, there were 23 students who did not like learning mathematics out of a total of 28 students with a presentation of 82% learning success. The average value of the math learning motivation indicator is obtained 2.64. These results identify that math learning motivation is still low.

Third, the results of the initial observation of the mathematics learning process of the material of the nets of beams and cubes in the classroom found that students were not serious in learning. Students are reluctant to study math in depth. The stimulus and response in the classroom are passive because during the learning process the teacher only explains the material by giving example problems and ends with students doing assignments. Learners are also less active in the learning process by listening and writing a lot. The learning resources used by teachers are also still centered on books and blackboards. This can be identified that the learning that is carried out is not varied and innovative. From the various preliminary studies above, it can be concluded that the determining factor that makes it difficult for students to understand mathematics material is that the learning alternatives used by teachers still do not support fun learning activities. This results in students not being motivated in learning math.

This research also supports previous research which states that there are still many students' math learning motivation that is still low and needs to be improved. Motivation to learn

mathematics is a problem that has not been resolved until now (Annisa et al., 2021) (Al-Amin & Murtiyasa, 2021; Al Husna et al., 2021; El-Adl & Alkharusi, 2020; Suren & Ali Kandemir, 2020; Rachmavita, 2020; Inganah et al., 2023; Filgona et al., 2020; Dierdorp, 2021; Sides & Cuevas, 2020).

To resolve these problems, researchers designed a solution in the form of STEAM-based learning. STEAM-based learning is learning that integrates five fields of science, namely science, technology, engineering, art and mathematics. Through STEAM-based learning, it can increase children's enthusiasm for learning, invite children to be creative without limits and carry out experimental activities in the learning process (Hendri et al., 2022; Maarang et al., 2023; Fitri & Suryana, 2022; Nurwulan, 2020).

STEAM-based learning can be said to be one form of effective learning in math lessons. With STEAM, students can be more interested in learning math so that there is a sense of spirit in learning. Expected results after using STEAM learning in the classroom student responses in learning mathematics become positive and make math a favorite subject (Hayati et al., 2023; Pant et al., 2020; Lin & Tsai, 2021; Conradty & Bogner, 2020).

This study aims to analyze the application of STEAM-based learning to increase motivation to learn mathematics on the material of the nets of blocks and cubes in class IV SDN 13 Langsa. The benefits of this research for teachers as a reference for innovative learning in increasing motivation to learn mathematics, for schools as an alternative reference for innovative forms of learning to overcome the problems of students' motivation to learn mathematics at school, for students as an effort to increase students' motivation to learn mathematics with the use of STEAM-based learning so that students can be motivated in learning mathematics at school.

RESEARCH METHODOLOGY

This study used Classroom Action Research. This research was conducted to overcome the problems of the learning process in the classroom resulting in low motivation to learn mathematics. This research was conducted at SDN 13 Langsa in the even semester of the 2023/2024 school year. The object of research focuses on math learning motivation on the material of the nets of blocks and cubes. The subject of this research focuses on fourth grade students of SDN 13 Langsa with a total of 28 students. The research stages consist of planning, implementation, observation and reflection. In the planning stage, prepare materials that support the learning process such as learning scenarios, media aids, observation sheets, and learning evaluations. At the implementation stage, two cycles were carried out consisting of three meetings in one cycle. At the observation stage, it is carried out to see teacher activities, student activities, and the implementation of learning steps. Observations were carried out by two observers. At the reflection stage, it is carried out by discussing various problems or weaknesses that arise during the learning process based on the results of observations of learning quality and data analysis of students' mathematics learning motivation. The type of data obtained consists of qualitative and quantitative data. Qualitative data was obtained using observation techniques. Quantitative data was obtained using a questionnaire sheet of mathematics learning motivation with a total of 25 statement items. Qualitative data analysis used descriptive analysis based on data obtained from observations of teacher activities and student activities. Quantitative data analysis was carried out by scoring each aspect and the overall level of students' mathematics learning motivation which was tabulated in tables, graphs and interpretation with percentages to determine the increase in students' learning motivation. Indicators of success of individual students' mathematics learning motivation with a range of 76-100 very high category. Classical learning completeness at a percentage of 78%.

RESULT AND DISCUSSION

Planning

In the planning stage, it starts with preparing learning models, learning tools, learning media that are in accordance with the needs of students in learning, this will have an impact on students' motivation to learn mathematics. If the planning is not well prepared, the motivation to learn mathematics does not get good results. The planning stage is used in both cycle I and cycle II. The planning stages that are prepared in general are as follows: (1) Develop teaching modules using STEAM-based learning with the material of the nets of class IV beams and cubes; (2) Develop student worksheets (LKPD) as experimental materials in STEAM-based learning activities; (3) Develop observation sheets for teacher activities and student activities; (4) prepare a mathematics learning motivation questionnaire which is a reference for assessing learning motivation; (5) prepare learning media used as a tool in the learning process; (6) Develop a teaching schedule; (7) Coordinate with the principal and class teacher regarding the implementation schedule that will be carried out at each session.

Implementation

Implementation is carried out by presenting the learning process using STEAM-based learning. In general, planning can be arranged through the following procedure steps: (1) Initial orientation, explanation of learning objectives and STEAM-based learning steps; (2) The teacher invites students to observe natural phenomena around related to blocks and cubes, this is integrated in Science; (3) The teacher and students ask questions related to the observations that occur; (4) The teacher explains the material using learning media such as boxes, rubiks, pictures and videos; (5) Learners are divided into several groups randomly; (6) The teacher provides STEAM-based LKPD on the material of the nets of blocks and cubes to groups of students, this is integrated in Mathematic; (7) The teacher explains the instructions in working on STEAM-based LKPD which contains STEAM experiments / projects that will produce STEAM objects resulting from the creativity of students; (8) Each group is given freedom in working on STEAM experiments both from the results or the process; (9) In the Tecnology point, the teacher invites using various tools and materials that have been provided in making and working on STEAM projects; (10) At the Engginering point, learners are given freedom according to their respective creativity to make designs or patterns as well as in assembling and designing STEAM media or projects; (11) After the STEAM project or media is almost complete, each group of learners gives color and adds other trinkets, this refers to the Art point; (12) Learners present the results of the work both in terms of results and processes; (13) Other learners provide comments and responses to the results of the project work displayed; (14) The teacher together with the learners make learning conclusions.

Observation

Observation is conducted to assess the quality of STEAM-based learning. Observations focus on teacher and student activities and the achievement of STEAM learning. Observations were made during the implementation of learning observed by peers and teachers. Observation is also assisted by video recording during the learning process to double-check the accuracy of the teacher activity observation assessment. The results obtained from the observation of learning quality in cycle I are as follows:

Table 1. Recapitulation of cycle i learning quality

No	Observer	Session 1	Session 2	Session3	Average(%)	Meaning
1	1	44	96	96	78,66%	Very High
2.	2	44	95	96	78,33%	Very High
		Total			156,99	-

No	Observer	Session 1	Session 2	Session 3	Average(%)	Meaning
Average					78,49%	Complete

From table 1 above, it shows that the quality of learning carried out by researchers is 78.49% with a very high interpretation. However, there are some actions that have not shown well, such as in terms of developing mathematics learning using STEAM-based learning. Some notes regarding the results of reflection on the quality of the learning process in cycle I are that the teacher does not give appreciation, positive attitudes and appreciates the answers given by students, the lack of cooperation of students in groups makes the class passive when asking questions, there are still many students who have not been able to solve problems quickly, and there are students who take a long time in the process of working on tasks so that they are left far behind by their friends. The results obtained from observing the quality of learning in cycle II are as follows:

Tabel 2. Recapitulation of cycle II learning quality

No	Observer	Session 1	Session 2	Session 3	Average (%)	Meaning
1	1	88	92	93	91,00%	Very High
2.	2	86	86	92	88,00%	Very High
Total					179,00	-
Average					89,50%	Complete

Table 2 above shows that the quality of learning carried out by researchers is 89.50% with a very high interpretation. This means that the process of STEAM-based learning activities is getting better. The learning management carried out by the teacher is also at a good level. This means that the minimum expected learning practices have been achieved and recommended to be maintained.

Results of Increased Motivation to Learn Mathematics Students using STEAM-Based Learning

Students' motivation to learn mathematics was obtained using a questionnaire. The questionnaire was filled in by each student. The questionnaire is to measure students' mathematics learning motivation and has been validated by expert lecturers and is suitable for use. The results of math learning motivation in cycle I are as follows:

Table 3. Results of students' mathematics learning motivation in cycle I

No	Indicator	Average
1	Persevere in facing tasks	3,04
2	Tenacious in the face of adversity	3,3
3	Showing interest	3,2
4	Enjoys working independently	3,1
5	Can defend his/her opinion	3,07
Total		16
Average		3,2

Table 3 above shows that all indicators of students' mathematics learning motivation have received an average score of 3 with a high category. However, the completeness of students' mathematics learning motivation has not increased significantly. When viewed from the success of student learning, it was found that 19 students reached the complete category with a percentage of 68% and there were 9 students who reached the unfinished category with a percentage of 32%. From this data, learning success has not yet reached the predetermined indicators, therefore it is necessary to improve in the next cycle. After planning, the implementation of STEAM-based learning in cycle II obtained the results of students' mathematics learning motivation, namely as follows:

Table 4. Results of students' mathematics learning motivation in cycle II

No	Indicator	Average
1	Persevere in facing tasks	3,84
2	Tenacious in the face of adversity	3,85
3	Showing interest	3,79
4	Enjoys working independently	3,85
5	Can defend his/her opinion	3,89
	Total	19
	Average	3,8

Table 4 above shows that all indicators of students' mathematics learning motivation have received an average score of 3.8 with a very high category. The completeness of students' mathematics learning motivation has increased significantly. The success of student learning was found that 19 students had reached the complete category with a percentage of 100%. From this data, researchers did not continue in the next cycle.

Discussion

The research findings show that the application of STEAM-based learning can increase students' motivation to learn mathematics in elementary schools. Students look very enthusiastic in learning because of the STEAM concept that makes students learn by integrating five different fields of science arranged in project activities and results in increased student abilities in the cognitive, affective and psychomotor domains (Nurhikmayati, 2019; Mu'minah & Suryaningsih, 2020; Andhianto et al., 2024; Handayani et al., 2023; Conradty & Bogner, 2020; Lin & Tsai, 2021; Wu et al., 2022; Suryaningsih et al., 2022; Mater et al., 2023; Nuraini et al., 2023).

The early activities in STEAM learning must present problems that are contextual in nature. This allows students to think about finding solutions that must be resolved immediately. The teacher stimulates students with important questions that exist in real life. Students together with the teacher make hypotheses and conjectures to see the activities and activities carried out in answering these questions. (Rakhmawati et al., 2024; Khusna & Shufa, 2024; Suganda et al., 2021).

In the STEAM-based learning process, students are required to carry out project activities that build student involvement in group learning and independent activities. This trains students to be responsible for their own tasks (Nuragnia et al., 2021; Kurniawati & Siswanto, 2024; Sigit et al., 2022; Adriyawati et al., 2020). In addition, the use of media, simple technology tools and student worksheets are important factors in classroom learning. These supports make students tend to be more active in learning. Completing worksheets in groups and independently trains students to discuss and build social and interpersonal skills in themselves (Rakhmawati et al., 2024; Herro et al., 2017; Zamrudah & Subekti, 2024; Mariano & Chiappe, 2021).

The impact of learning motivation behavior can be seen that students begin to experience changes, students become more confident in giving opinions and try to learn independently by looking for information with various other sources related to the material they want to learn. This relates that learning motivation must indeed be present in students both from an intrinsic and extrinsic perspective in making changes in the learning process (Wu et al., 2022; Mater et al., 2023; Alcantara, 2020; Jia et al., 2021; Amalia et al., 2021; Thuneberg et al., 2018).

In the end, the implementation of STEAM-based learning makes the learning environment and atmosphere more active and fun. Project activities based on real-world problems make curiosity high and develop creative thinking skills by combining art elements in the learning process. (Lin & Tsai, 2021; Suryaningsih et al., 2022; Conradty & Bogner, 2020; Pahmi et al., 2022; Mater et al., 2023; Khusna & Shufa, 2024; Syukri et al., 2022; Kurniawati & Siswanto, 2024).

CONCLUSION

The implementation of STEAM-based learning (Science, Technology, Engineering, Art and Mathematic) in mathematics learning in class IV SDN 13 Langsa can increase students' motivation to learn mathematics in each cycle. STEAM-based math learning (Science, Technology, Engineering, Art and Mathematic) at SDN 13 Langsa received enthusiasm and a very good response from students. Students are more active and creative in learning when discussing worksheets and carrying out project activities. The implementation of STEAM-based learning provides experience for students to have an attitude of responsibility for their duties, collaboration, and self-confidence. In the first cycle assessment, students who were complete amounted to 19 students with a percentage of 86%. This has not yet reached learning completeness. Based on these results, researchers want to further increase the level of success to see the consistency of students in the learning process. Furthermore, corrective action was given in cycle II and there was an increase, students who completed 28 students with a percentage of 100%. Based on the results of this study, STEAM-based learning can be used as an alternative in variations in the application of mathematics learning in elementary schools. The limitations of this study only focus on the application of learning alternatives in an effort to increase student learning motivation in a small scope. The data used to obtain the results of learning motivation is only single and needs further confirmation from the students. Suggestions for future research can be made to develop variations in the implementation of STEAM-based learning at various school levels and pay attention to increasing other variables such as mathematical abilities that adjust student characteristics and diverse environmental conditions. Such research can provide a more in-depth view of the potential and limitations of STEAM-based learning implementation, as well as provide support for innovative learning practices that suit future educational challenges.

References

- Adriyawati, Utomo, E., Rahmawati, Y., & Mardiah, A. (2020). STEAM-Project-Based Learning Integration to Improve Elementary School Students' Scientific Literacy on Alternative Energy Learning. *Universal Journal of Educational*, 8, 1863–1873. <https://doi.org/10.13189/ujer.2020.080523>
- Al-Amin, Y., & Murtiyasa, B. (2021). Analisis Kesulitan Belajar Matematika pada Proses Pembelajaran Daring Menggunakan Metode Pembelajaran Berbasis Masalah. *Kontinu: Jurnal Penelitian Didaktik Matematika*, 5(1), 49–65. <https://doi.org/http://dx.doi.org/10.30659/kontinu.5.1.49-65>
- Al Husna, L., MZ, Z. A., & Rian Vebrianto. (2021). Studi Eksploratif Problematika Pembelajaran Matematika Di Sekolah Dasar Di Tanah Datar. *Mathline : Jurnal Matematika Dan Pendidikan Matematika*, 6(1), 1–12. <https://doi.org/10.31943/mathline.v6i1.159>
- Alcantara, I. (2020). Students' Self-Confident in STEAM. *Schrödinger: Journal of Physics Education*, 1(2), 67–73. <https://doi.org/10.37251/sjpe.v1i2.66>
- Amalia, D., Sutarto, J., & Pranoto, Y. K. S. (2021). The Effect of Steam Loading Distance Learning on Creative Character and Independence. *ThufuLA: Jurnal Inovasi Pendidikan Guru Raudhatul Athful*, 9(2), 221. <https://doi.org/10.21043/thufula.v9i2.11483>
- Andhianto, P. A., Fitriani, Y., & Nuroniah, P. (2024). Penerapan Pembelajaran STEAM Berbasis Proyek Penguatan Profil Pelajar Pancasila (P5) di Satuan PAUD. *Jurnal Pendidikan Anak Usia Dini*, 5(1), 314–326. <https://doi.org/10.37985/murhum.v5i1.547>
- Anggraini, Y. (2021). Analisis Persiapan Guru dalam Pembelajaran Matematika di Sekolah Dasar. *Jurnal Basicedu*, 5(4), 2415–2422. <https://doi.org/https://doi.org/10.31004/basicedu.v5i4.1241>
- Annisa, MZ, Z. A., & Vebrianto, R. (2021). Problematika Pembelajaran Matematika di SD Muhammadiyah Kampa Full Day School. *El-Ibtidaiy:Journal of Primary Education*, 4(1), 95–105. <https://doi.org/10.24014/ejpe.v4i1.11655>
- Conradty, C., & Bogner, F. X. (2020). STEAM teaching professional development works: effects on students' creativity and motivation. *Smart Learning Environments*, 7(26), 1–20. <https://doi.org/10.1186/s40561-020-00132-9>
- Dierdorff, A. (2021). Evidence-informed teaching: Investigating whether evidence from 'flipping the

- classroom' research improves students' motivation for mathematics. *Education Sciences*, 11(6), 1–15. <https://doi.org/10.3390/educsci11060257>
- El-Adl, A., & Alkharusi, H. (2020). Relationships between self-regulated learning strategies, learning motivation and mathematics achievement. *Cypriot Journal of Educational Sciences*, 15(1), 104–111. <https://doi.org/10.18844/cjes.v15i1.4461>
- Farhan, M., Hakim, A. R., & Apriyanto, M. T. (2022). Kontribusi Kecerdasan Emosional Terhadap Motivasi Belajar Siswa Pada Pembelajaran Matematika. *Plusminus: Jurnal Pendidikan Matematika*, 2(3), 417–428. <https://doi.org/10.31980/plusminus.v2i3.1867>
- Filgona, J., Sakiyo, J., Gwany, D. M., & Okoronka, A. U. (2020). Motivation in Learning. *Asian Journal of Education and Social Studies*, 10(4), 16–37. <https://doi.org/10.9734/ajess/2020/v10i430273>
- Fitri, D. A. N., & Suryana, D. (2022). Pembelajaran STEAM dalam Mengembangkan Kemampuan Kreativitas Anak Usia Dini. *Jurnal Pendidikan Tambusai*, 6(2), 12545.
- Gusteti, M. U., & Neviyarni, N. (2022). Pembelajaran Berdiferensiasi Pada Pembelajaran Matematika Di Kurikulum Merdeka. *Jurnal Lebesgue : Jurnal Ilmiah Pendidikan Matematika, Matematika Dan Statistika*, 3(3), 636–646. <https://doi.org/10.46306/lb.v3i3.180>
- Hallifax, S., Lavoué, E., & Serna, A. (2020). To tailor or not to tailor gamification? An analysis of the impact of tailored game elements on learners' behaviours and motivation. *Artificial Intelligence in Education, Lecture No*, 216–227. https://doi.org/10.1007/978-3-030-52237-7_18
- Handayani, W., Kuswandi, D., Akbar, S., & Arifin, I. (2023). Pembelajaran Berbasis STEAM untuk Perkembangan Kognitif pada Anak. *Murhum: Jurnal Pendidikan Anak Usia Dini*, 4(2), 770–778. <https://doi.org/10.37985/murhum.v4i2.390>
- Hayati, R., Prima, W., Wulandari, S., Yunita, A. P., Mulyati, A., & Azmi, K. (2023). Model Pembelajaran STEAM (Science, Techonology, Engineering, Art, and Math) dalam Pembelajaran Matematika Sekolah Dasar: Pembelajaran Berdiferensiasi. *Edukatif: Jurnal Ilmu Pendidikan*, 5(6), 2591–2603. <https://doi.org/10.31004/edukatif.v5i6.5723>
- Hendri, S., Kenedi, A. K., & Handika, R. (2022). *Stem Dalam Pembelajaran Matematika Sekolah Dasar (Pertama)*. PACE.
- Hendriani, M., Jamaris, & Marsyidin, S. (2023). Kemampuan Pemecahan Masalah Dalam Pembelajaran Matematika Berbasis Persepsi Guru Sekolah Dasar. *Jurnal Inovasi Pendidikan Dan Pembelajaran Sekolah Dasar (JIPPSD)*, 7(2), 361–371. <http://ejournal.unp.ac.id/index.php/jippsd/indexDOI:https://doi.org/10.24036/jippsd.v7i2>
- Herro, D., Quigley, C., Andrews, J., & Delacruz, G. (2017). Co-Measure: developing an assessment for student collaboration in STEAM activities. *International Journal of STEM Education*, 4(26). <https://doi.org/10.1186/s40594-017-0094-z>
- Husna, R., Roza, Y., & Maimunah, M. (2021). Identifikasi Kesulitan Guru Matematika Dalam Pelaksanaan Pembelajaran Daring di Masa Pandemi Covid-19. *Jurnal Kependidikan: Jurnal Hasil Penelitian Dan Kajian Kepustakaan Di Bidang Pendidikan, Pengajaran Dan Pembelajaran*, 7(2), 428–436. <https://doi.org/10.33394/jk.v7i2.3333>
- Inganah, S., Darmayanti, R., & Rizki, N. (2023). Problems, Solutions, and Expectations: 6C Integration of 21 st Century Education into Learning Mathematics. *JEMS (Journal of Mathematics and Science Education)*, 11(1), 220–238.
- Intan, D. N., Kuntarto, E., & Sholeh, M. (2022). Strategi Guru untuk Mencapai Tujuan Pembelajaran pada Pembelajaran Matematika di Sekolah Dasar. *Jurnal Basicedu*, 6(3), 3302–3313. <https://doi.org/10.31004/basicedu.v6i3.2287>
- Ismail, R. (2018). Perbandingan Keefektifan Pembelajaran Berbasis Proyek dan Pembelajaran Berbasis Masalah Ditinjau dari Ketercapaian Tujuan Pembelajaran. *Pythagoras: Jurnal Pendidikan Matematika*, 13(2), 181–188. <https://doi.org/https://doi.org/10.21831/pg.v13i2.23595>
- Isnawan, M. G., & Wicaksono, A. B. (2018). Model Desain Pembelajaran Matematika. *Indonesian Journal of Mathematics Education*, 1(1), 47–52. <https://doi.org/10.31002/ijome.v1i1.935>
- Jia, Y., Zhou, B., & Zheng, X. (2021). A Curriculum Integrating STEAM and Maker Education Promotes Pupils' Learning Motivation, Self-Efficacy, and Interdisciplinary Knowledge Acquisition. *Frontiers in Psychology*, 12(September), 1–10. <https://doi.org/10.3389/fpsyg.2021.725525>
- Kamarullah, K. (2017). Pendidikan Matematika Di Sekolah Kita. *Al Khawarizmi: Jurnal Pendidikan Dan Pembelajaran Matematika*, 1(1), 21–32. <https://doi.org/10.22373/jppm.v1i1.1729>

- Khusna, N., & Shufa, F. (2024). Pembelajaran Terintegrasi STEAM berbasis Kearifan Lokal : Strategi Signifikan dalam Meningkatkan 4 Cs di Abad 21. *Prosiding Seminar Nasional Ilmu Pendidikan*, 55–67.
- Kurniawati, V., & Siswanto. (2024). Application of STEAM method in learning in madrasah to improve student understanding. *Jurnal Inovasi Teknologi Pendidikan*, 11(2), 160–171.
- Lestari, S. (2021). Pembelajaran Daring Pada Mata Pelajaran Matematika Sekolah Dasar. *JMIE (Journal of Madrasah Ibtidaiyah Education)*, 5(1), 141–155. <https://doi.org/10.32934/jmie.v5i1.226>
- Lin, C.-L., & Tsai, C.-Y. (2021). The Effect of a Pedagogical STEAM Model on Students' Project Competence and Learning Motivation. *Journal of Science Education and Technology*, 30(1), 112–124. <https://doi.org/10.1007/s10956-020-09885-x>
- Maarang, M., Khotimah, N., & Maria Lily, N. (2023). Analisis Peningkatan Kreativitas Anak Usia Dini melalui Pembelajaran STEAM Berbasis Loose Parts. *Murhum : Jurnal Pendidikan Anak Usia Dini*, 4(1), 309–320. <https://doi.org/10.37985/murhum.v4i1.215>
- Mariano, W. K., & Chiappe, A. (2021). 21st-century skills and their relationship to STEAM learning environments: A review. *Revista de Educación a Distancia*, 21(66). <https://doi.org/10.6018/red.470461>
- Mater, N., Daher, W., & Mahamid, F. (2023). The Effect of STEAM Activities Based on Experiential Learning on Ninth Graders' Mental Motivation. *European Journal of Investigation in Health, Psychology and Education*, 13(7), 1229–1244. <https://doi.org/10.3390/ejihpe13070091>
- Maulyda, M. A. (2020). *Paradigma Pembelajaran Matematika Berbasis NCTM (Pertama, Issue January)*. CV IRDH.
- Mu'minah, I. H., & Suryaningsih, Y. (2020). Implementasi STEAM (Science, Technology, Engineering, Arts and Mathematics) dalam Pembelajaran Abad 21. *Jurnal Bio Education*, 5(1), 65–73.
- Munthe, L. S., & Pasaribu, L. H. (2023). Pengaruh Minat dan Motivasi Belajar Siswa Terhadap Prestasi Belajar Matematika. *Jurnal Cendekia : Jurnal Pendidikan Matematika*, 7(2), 1321–1331. <https://doi.org/10.31004/cendekia.v7i2.2087>
- Nasrah, N., & Muafiah, A. M. A. (2020). Analisis motivasi belajar dan hasil belajar daring mahasiswa pada masa pandemik Covid-19. *JRPD (Jurnal Riset Pendidikan Dasar)*, 3(2), 207–213
- NCTM. (2000). *Principles and Standards for School Mathematics*. VA: NCTM. <https://doi.org/10.5951/at.29.5.0059>
- Nuragnia, B., Nadiroh, & Usman, H. (2021). Pembelajaran Steam Di Sekolah Dasar : Implementasi Dan Tantangan. *Jurnal Pendidikan Dan Kebudayaan*, 6(2), 187–197. <https://doi.org/10.24832/jpnk.v6i2.2388>
- Nuraini, N., Asri, I. H., & Fajri, N. (2023). Development of Project Based Learning with STEAM Approach Model Integrated Science Literacy in Improving Student Learning Outcomes. *Jurnal Penelitian Pendidikan IPA*, 9(4), 1632–1640. <https://doi.org/10.29303/jppipa.v9i4.2987>
- Nurhikmayati, I. (2019). Implementasi STEAM Dalam Pembelajaran Matematika. *Didactical Mathematics*, 1(2), 41–50. <https://doi.org/10.31949/dmj.v1i2.1508>
- Nurwulan, N. R. (2020). Pengenalan Metode Pembelajaran STEAM Kepada Para Siswa Tingkat Sekolah Dasar Kelas 1 Sampai 3. *Jurnal Madaniya*, 1(3), 140–146.
- Pahmi, S., Juandi, D., & Sugiarni, R. (2022). The Effect of STEAM in Mathematics Learning on 21st Century Skills: A Systematic Literature Reviews. *Prisma*, 11(1), 93. <https://doi.org/10.35194/jp.v11i1.2039>
- Pant, B. P., Luitel, B. C., & Shrestha, I. M. (2020). Incorporating STEAM Pedagogy in Teaching Mathematics. *International Conference to Review Research in Science, Technology and Mathematics Education, January*, 319–326. <https://www.researchgate.net/publication/338343451>
- Rachmavita, F. P. (2020). Interactive media-based video animation and student learning motivation in mathematics. *Journal of Physics: Conference Series*, 1663(1). <https://doi.org/10.1088/1742-6596/1663/1/012040>
- Raj Acharya, B. (2017). Factors Affecting Difficulties in Learning Mathematics by Mathematics Learners. *International Journal of Elementary Education*, 6(2), 8–15. <https://doi.org/10.11648/j.ijeeu.20170602.11>
- Rakhmawati, E., Riniati, W. O., Badriyah, B., & Irmawati, I. (2024). Implementasi Pembelajaran STEAM pada Kelas Rendah di Sekolah Dasar. *Al-Madrasah: Jurnal Pendidikan Madrasah Ibtidaiyah*, 8(1), 127. <https://doi.org/10.35931/am.v8i1.2930>
- Sides, J. D., & Cuevas, J. A. (2020). Effect of goal setting for motivation, self-efficacy, and performance in elementary mathematics. *International Journal of Instruction*, 13(4), 1–16. <https://doi.org/10.29333/iji.2020.1341a>
- Sigit, D. V., Ristanto, R. H., & Mufida, S. N. (2022). Integration of Project-Based E-Learning with STEAM: An Innovative Solution to Learn Ecological Concept. *International Journal of Instruction*, 15(3), 23–40. <https://doi.org/10.29333/iji.2022.1532a>

- Sudibyo, E., Jatmiko, B., & Widodo, W. (2016). Pengembangan instrumen motivasi belajar fisika: angket. *JPPIPA (Jurnal Penelitian Pendidikan IPA)*, 1(1), 13-21
- Suganda, E., Latifah, S., Irwandani, Sari, P. M., Rahmayanti, H., Ichsan, I. Z., & Rahman, M. M. (2021). STEAM and Environment on students' creative-thinking skills: A meta-analysis study. *Journal of Physics: Conference Series*, 1796(1). <https://doi.org/10.1088/1742-6596/1796/1/012101>
- Suren, N., & Ali Kandemir, M. (2020). The effects of mathematics anxiety and motivation on students' mathematics achievement. *International Journal of Education in Mathematics, Science and Technology*, 8(3), 190-218. <https://doi.org/10.46328/IJEMST.V8I3.926>
- Suryaningsih, S., Nisa, F. A., Muslim, B., & Aldiansyah, F. (2022). Learning Innovations: Students' Interest and Motivation on STEAM-PjBL. *International Journal of STEM Education for Sustainability*, 2(1), 66-77. <https://doi.org/10.53889/ijses.v2i1.40>
- Syukri, M., Ukhaira, Z., Zainuddin, Z., Herliana, F., & Arsad, N. M. (2022). The Influence of STEAM-Based Learning Application on Students' Critical Thinking Ability. *Asian Journal of Science Education*, 4(2), 37-45. <https://doi.org/10.24815/ajse.v4i2.28272>
- Szabo, Z. K., Körtesi, P., Guncaga, J., Szabo, D., & Neag, R. (2020). Examples of problem-solving strategies in mathematics education supporting the sustainability of 21st-century skills. *Sustainability (Switzerland)*, 12(23), 1-28. <https://doi.org/10.3390/su122310113>
- Tabuena, A. C., & Pentang, J. (2021). Learning Motivation and Utilization of Virtual Media in Learning Mathematics. *Asia-Africa Journal of Recent Scientific Research (AAJRSR)*, 1, 65-75.
- Thuneberg, H. M., Salmi, H. S., & Bogner, F. X. (2018). How creativity, autonomy and visual reasoning contribute to cognitive learning in a STEAM hands-on inquiry-based math module. *Thinking Skills and Creativity*, 29(April), 153-160. <https://doi.org/10.1016/j.tsc.2018.07.003>
- Vankúš, P. (2021). Influence of game-based learning in mathematics education on students' affective domain: A systematic review. *Mathematics*, 9(9), 1-10. <https://doi.org/10.3390/math9090986>
- Vu, T., Magis-weinberg, L., & Jansen, B. R. J. (2022). Motivation-Achievement Cycles in Learning: a Literature Review and Research Agenda. *Educational Psychology Review*, 34, 39-71. <https://doi.org/https://doi.org/10.1007/s10648-021-09616-7>
- Wu, C. H., Liu, C. H., & Huang, Y. M. (2022). The exploration of continuous learning intention in STEAM education through attitude, motivation, and cognitive load. *International Journal of STEM Education*, 9(35). <https://doi.org/10.1186/s40594-022-00346-y>
- Zamrudah, Z., & Subekti, H. (2024). Implementation of STEAM Approach to Teach Collaboration Skills on Pollution Material in Junior High. *JOELI: Journal of Educational and Learning Innovation*, 1(1), 59-74.