**M A T H L I N E**
**JURNAL MATEMATIKA DAN PENDIDIKAN MATEMATIKA**
**ISSN 2502-5872 (Print)**
**ISSN 2622-3627 (Elektronik)**

Volume 10 Nomor 4, November 2025, 1029-1040

# ENHANCING LEARNING MANAGEMENT SKILLS OF PROSPECTIVE MATHEMATICS TEACHERS THROUGH A PROJECT-BASED LEARNING MODEL INTEGRATED WITH STEAM

**Fauziah[1*], Nuramaliyah Ramadhany [2], Herman Alimuddin[3], Nur Wahidin Ashari[4]**
[1,2,3]Program Studi Pendidikan Matematika, STKIP Andi Matappa Pangkep, Sulawesi Selatan, Indonesia
[4]Program Studi Pendidikan Matematika, Universitas Negeri Makassar, Sulawesi Selatan, Indonesia

*Correspondence: fauziah@matappa.ac.id

***ABSTRACT***
This study aims to improve the learning management skills of prospective mathematics teachers through the implementation of Project-Based Learning (PjBL) integrated with STEAM (Science, Technology, Engineering, Art, and Mathematics). The research employed a quantitative approach with a quasi-experimental design, specifically a pretest-posttest non-equivalent control group design. Two groups of students participated: the experimental group using the PjBL-STEAM model and the control group following conventional learning. The research instruments included a learning management competency test, a student perception questionnaire, and PjBL-STEAM-based learning materials. Data were analyzed using descriptive and inferential statistics (t-test and effect size) to evaluate the effectiveness of the model and examine students' perceptions of its implementation. The results revealed a significant improvement in the learning management skills of students in the experimental group compared to the control group. The PjBL-STEAM model effectively enhanced students' abilities in planning, implementation, evaluation, and reflection & improvement, while also promoting active engagement, creativity, and self-confidence. These findings suggest that integrating PjBL with STEAM can be an effective strategy to strengthen the pedagogical competencies of prospective mathematics teachers, preparing them to meet the demands of 21st-century education.
**Keywords:** Learning Management, Project-Based Learning, STEAM, Student Teachers, Mathematics Education.

**How to Cite:** Fauziah, F., Ramadhany, N., Alimuddin, H., & Ashari, N. W. (2025). Enhancing Learning Management Skills Of Prospective Mathematics Teachers Through A Project-Based Learning Model Integrated With STEAM. *Mathline: Jurnal Matematika dan Pendidikan Matematika, 10*(4), 1029-1040. http://doi.org/10.31943/mathline.v10i4.1034

## PRELIMINARY

The development of 21st-century education is progressing rapidly and requires prospective teachers, particularly mathematics teachers, to possess pedagogical skills that extend beyond the ability to deliver instruction in the classroom. One of the essential competencies they must master is learning management, which encompasses effective and meaningful planning, implementation, classroom management, and evaluation. In South

Sulawesi, several studies have shown that prospective mathematics teachers still face challenges in managing learning optimally, especially in adapting to the demands and needs of contemporary education (Manjani et al., 2024; Paulina, 2020; Santoso et al., 2020).

The Project-Based Learning (PjBL) model is an instant of the instructional approaches proven to enhance students' active engagement in the learning process. When colaborated with the STEAM approach (Science, Technology, Engineering, Art, and Mathematics), PjBL can facilitate pupil and pre-service teachers Strengthen critical thinking, creativity, collaboration, Together with communication skills, which are essential components of 21st-century learning. Studies conducted by (Hikmawan, 2022) research has Proven that the Realization of STEAM-based Project-Based Learning (PjBL) significantly enhances students' mathematical thinking skills and learning motivation. However, most applications of this approach have been concentrated at the secondary school level and have not yet been widely extended to teacher education.

At the higher education level, particularly in teacher training institutions (LPTK) in South Sulawesi, this approach is highly needed to support prospective teachers in improving their learning management skills. The quality of teacher education graduates has significant effect on how well learning takes place in schools. Therefore, implementing the PjBL-STEAM model for prospective mathematics teachers is a strategic step not only to develop academic abilities but also to strengthen managerial skills in designing and conducting innovative, contextual, and relevant learning in line with current educational developments.

Thus, this research is urgently needed as it addresses the demand for a learning model that can strengthen the competencies of prospective mathematics teachers, especially in terms of creative and transformative learning management in the STEAM era. Furthermore, the PjBL-STEAM model provides authentic and contextual learning experiences, which are essential in preparing pupils To navigate the complexities of the professional world, particularly in managing dynamic classrooms. The integration of PjBL-STEAM has been proven effective in enhancing the competencies of prospective mathematics teachers (Alimuddin et al., 2023; Naufal & Asdar, 2022; Palennari & Fauziyah, 2024; Rezkillah et al., 2024; Safriana et al., 2022).

Several previous studies have shown that the integration of STEAM in mathematics learning can enhance students' creativity, critical thinking skills, and conceptual understanding. However, these studies have generally focused on boosting the critical thinking, creativity, and conceptual understanding of school students rather than prospective teacher (Budiyono et al., 2023; Nada et al., 2023). Studies that specifically evaluate the

learning management skills of prospective mathematics teachers through the deploymet of a PjBL-STEAM model are still limited. Moreover, many previous studies have employed descriptive qualitative methods or pure experiments without control groups, whereas this experiment adopts a quasi-experimental design with a control group, which allows for a clearer comparison between the applied learning models.

The research problems of this experiment are specified as follows:

1. Is there a difference in the learning management skills of prospective mathematics teachers during the pre-implementation and post-implementation stages of the PjBL-STEAM model?
2. Does the implementation of the PjBL-STEAM model Impact significantly on improving the learning management skills of prospective mathematics teachers compared to conventional learning models?

## METHODS

This study employs a quantitative approach using a quasi-experimental method, as the researcher is unable to fully control external variables that may influence the outcomes (Sani, 2020; Sugiyono, 2019). The chosen methodology for this study is a pretest-posttest non-equivalent control group design. It involving two groups of prospective mathematics teachers. The two group are the experimental group, which engaged in learning through the PjBL-STEAM model, and the control group, which followed conventional learning. This design allows the researcher to probe the contrasts in improvement between the two groups (Denny et al., 2023).

The research flow diagram is presented in Figure 1 below

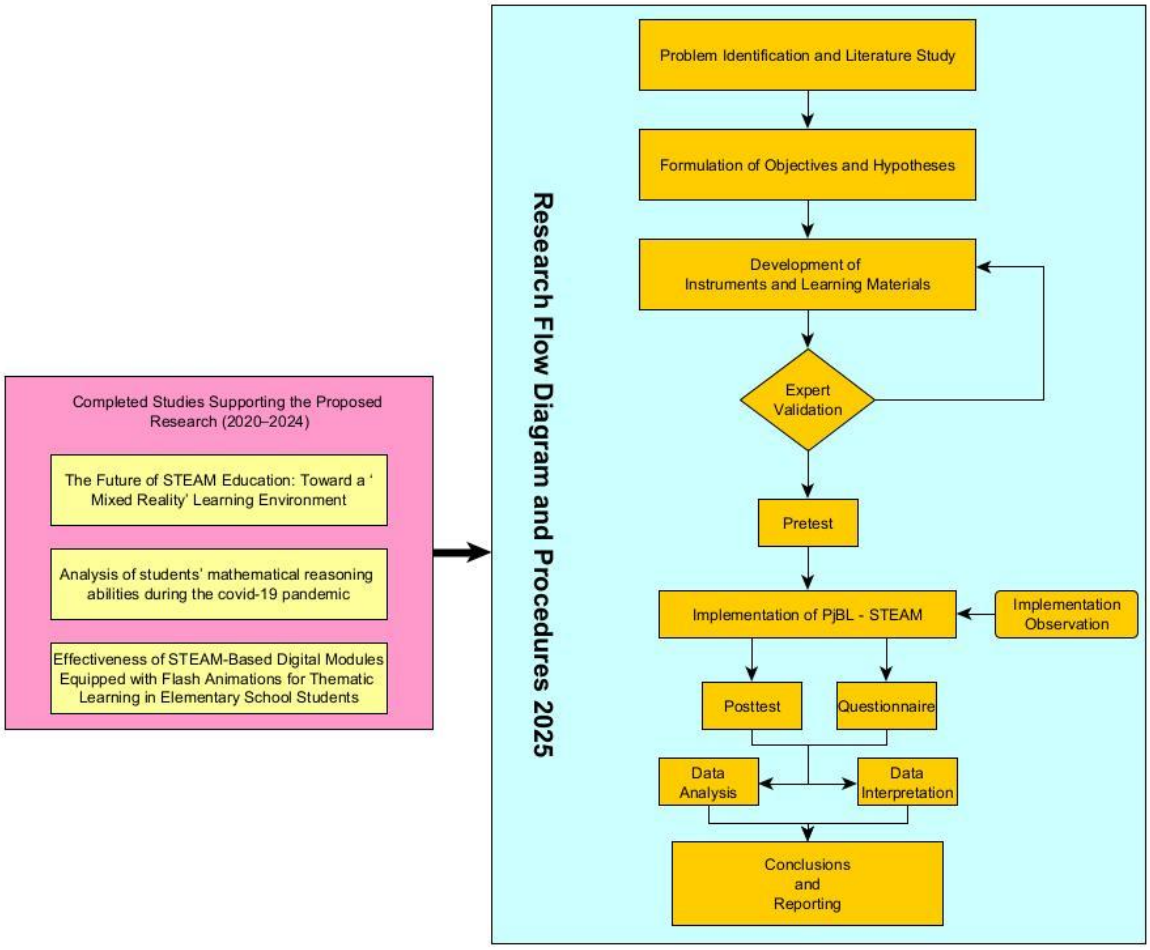


**Figure 1.** Research Flowcharts

Research Process and Achievement Indicators

a. Problem Identification and Literature Review

At this stage, a review of previous research findings, scientific journals, and preliminary observations was conducted to identify the needs for improving the competencies of prospective teachers, particularly in the aspect of learning management.

b. Formulation of Objectives and Hypotheses

Based on the problem identification and literature review, the researcher formulated the research objectives and working hypotheses to be tested statistically. The objectives and hypotheses were designed in alignment with the quasi-experimental approach employed.

c. Development of Instruments and Learning Tools

This stage included the preparation of research instruments consisting of: (a) a test of learning management competence that its indacator consist of Designing innovative project-based and STEAM-oriented learning experiences, implementing

effective project-based learning strategies, developing and interpreting project-based assessment results, reflecting on teaching practices and formulating improvement plans; (b) a student perception questionnaire regarding PjBL-STEAM learning that its indacators consist of Student engagement and motivation in participating in PjBL-STEAM activities, collaboration and communication effectiveness during project work, ability to think critically and solve problems through STEAM-integrated projects, perceived relevance and meaningfulness of integrating STEAM disciplines in real-world contexts, overall satisfaction and perceived learning benefits from the PjBL-STEAM experience.; and (c) learning tools such as syllabus, Instructional plans, student worksheets (LKPD) based on PjBL-STEAM, and observation sheets.

d. Validation

The instruments and learning tools developed were then validated by experts, including lecturers in mathematics education and specialists in PjBL-STEAM.

e. Implementation of the Quasi-Experiment

The population of this study consisted of prospective teacher students at STKIP Andi Matappa Pangkep, while the sample was purposively selected from sixth-semester students. There are 27 students for experimental grup and 22 students for control group. A Pretest-Posttest control group design in conducting the study, as presented in the table below. (Ary et al., 2014):

| | Pretest | Treatment | Postets |
|---|---|---|---|
| Experiment | $O_1$ | X | $O_2$ |
| Control | $O_1$ | | $O_2$ |

Hypothesis

H0 : There is no significant difference in learning management skills between prospective mathematics teachers who participated in the PjBL-STEAM model and those who followed conventional learning.

H1 : There is a significant difference in learning management skills between prospective mathematics teachers who participated in the PjBL-STEAM model and those who followed conventional learning.

a. Data Analysis and Conclusion Drawing

The data in this study a quantitative methodology was applied, incorporating descriptive and inferential statistical procedures. Descriptive statistics were employed to outline the basic characteristics of the data. to obtain an overview of the learning management skills of prospective mathematics teachers in both the experimental and control groups, before and after the treatment. This analysis included the mean, standard deviation, maximum, and minimum scores.

To evaluate the prerequisites for conducting parametric statistical analyses, normality tests were conducted using the Kolmogorov-Smirnov or Shapiro-Wilk test, and homogeneity of variance was tested using Levene's Test. If both assumptions were met, hypothesis testing was carried out using the t-test. A paired sample t-test was applied to determine the improvement in learning management skills within each group (pretest–posttest), while an independent sample t-test was used to examine contrasts between the experimental and control groups at the posttest stage. If the data did not meet the normality assumption, non-parametric tests.

Furthermore, to determine the effectiveness of the PjBL-STEAM model, effect size analysis using Cohen's d was applied. This analysis purposed to determine the magnitude of the model's impact on improving students' learning management skills. The interpretation of effect size was based on the following criteria

**Table 1. Effect Size**

| No | Score d | Criteria |
|---|---|---|
| 1 | d < 0,3 | Low |
| 2 | d ≈ 0,5 | Moderate |
| 3 | d > 0,8 | High |

A student perception questionnaire on the implementation of PjBL-STEAM was administered. The questionnaire utilized a quantitative descriptive approach by calculating the mean score of each item. The results were then classified into categories of very high, high, moderate, low, or very low based on a Likert scale using the following formula.

$$Mean\ Skor = \frac{\sum(Score\ of\ Total\ Respondent)}{Sum\ of\ Responden}$$

## RESULT AND DISCUSSION

1) Deskriptive Analysis

**Table 2. Deskriptive Analysis**

| Statistics | Eksperimen | | | Control | | |
|---|---|---|---|---|---|---|
| | Pretest | Postest | Gain | Pretest | Postest | Gain |
| Mean | 44,86 | 90,79 | 0,83 | 45,97 | 82,59 | 0,68 |

| Statistics | Eksperimen | | | Control | | |
|---|---|---|---|---|---|---|
| | Pretest | Postest | Gain | Pretest | Postest | Gain |
| Median | 45,71 | 91,42 | 0,83 | 44,28 | 82,85 | 0,68 |
| Variance | 90,94 | 27,84 | 0,01 | 101,79 | 75,36 | 0,02 |
| Std. Deviation | 9,54 | 5,28 | 0,08 | 10,09 | 8,68 | 0,16 |
| Minimum | 28,57 | 80,00 | 0,65 | 31,42 | 65,71 | 0,40 |
| Maximum | 65,71 | 100,00 | 1,00 | 62,85 | 100,00 | 1,00 |
| Range | 37,14 | 20,00 | 0,35 | 31,43 | 34,29 | 0,60 |

In the experimental group, the mean pretest score was 44.86 with a median of 45.71 and a standard deviation of 9.54, indicating that students' initial abilities were relatively low with moderate variation. Once the STEAM-PjBL model had been implemented, the mean posttest score increased to 90.79 with a median of 91.42 and a standard deviation of 5.28. These results demonstrate a significant improvement in students' learning management skills. The gain scores ranged from 0.65 to 1.00 with an average of 0.83, indicating that all students experienced progress, although the degree of improvement varied across individuals. The posttest range of 0.35 Highlights that predominantly of students achieved high scores.

In the control group, the mean pretest score was 45.97 with a median of 44.28 and a standard deviation of 10.09, showing that students' initial abilities were almost equivalent to those of the experimental group. After receiving conventional instruction, the mean posttest score increased to 82.59 with a median of 82.85 and a standard deviation of 8.68, indicating an improvement in students' learning management skills. The gain scores ranged from 0.40 to 1.00 with an average of 0.68. The posttest range of 34.29 indicates a wider distribution of scores compared to the pretest, with some students achieving high scores while others remained below the average.

2) Assumption Tests for Analysis

Before conducting hypothesis testing, assumption tests were carried out, namely normality and homogeneity tests, on both the experimental and control groups. The normality test aimed to determine whether the distribution of students' learning management skill scores followed a normal distribution pattern.

**Table 3. Normality Test**

| Group | | Statistic | degrees of freedom | Sig. |
|---|---|---|---|---|
| Pretest | Control | 0,127 | 22 | 0,200 |
| | Experiment | 0,127 | 27 | 0,200 |
| Postest | Control | 0,087 | 22 | 0,200 |
| | Experiment | 0,153 | 27 | 0,104 |
| Gain | Control | 0,102 | 22 | 0,200 |
| | Experiment | 0,100 | 27 | 0,200 |

The significance (Sig.) values for the control and experimental groups in the pretest were 0.200 and 0.200, respectively, while in the posttest they were 0.200 for the control group and 0.104 for the experimental group. For the gain scores, the Sig. value was 0.200 for both groups. Since all significance values were greater than 0.05, it can be inferred that the pretest, posttest, and gain data for both groups met the assumption of normality.

**Table 4. Homogenity Test**

| | Levene | degrees of freedom 1 | degrees of freedom 2 | Sig. |
|---|---|---|---|---|
| Mean Based | 4,013 | 1 | 47 | 0,051 |

The results of the homogeneity of variance test using Levene's Test showed a Levene Statistic value of 4.013 with df1 = 1 and df2 = 47, and a significance (Sig.) value of 0.051. Since the Sig. value was greater than 0.05, it can be concluded that the variance of learning management skill scores between the experimental and control groups was relatively homogeneous. As the data in both groups met the assumption tests—normal distribution based on the Kolmogorov-Smirnov test and homogeneity of variance based on Levene's Test—the subsequent analysis could be continued with hypothesis testing.

3) Uji Paired Test

**Table 5. Paired Sample Test**

| | Mean | St. Deviation | t | df | Sig. (2-tailed) |
|---|---|---|---|---|---|
| Pre_Eksperimen - Post_Eksperimen | -45,93 | 7,68 | -31,08 | 26 | 0,00 |

Based on the table above, since As the p-value falls below the 0.05 threshold, it can be inferred that a significant distinction exists in learning management skills between prospective mathematics teachers who participated in the STEAM-integrated PjBL learning model and those who followed conventional instruction.

4) Independent sample t-test

**Table 6. Independent Sample T-Test**

| | Sig. (2-tailed) | Mean Difference | Std. Error Difference | 95% Confidence Interval of the Difference | |
|---|---|---|---|---|---|
| | | | | Lower | Upper |
| Gain | 0,000 | 0,15490 | 0,03487 | 0,08474 | 0,22506 |

Based on the table above, since the significance value is less than 0.05, it can be concluded that there is a significant improvement in learning management skills between prospective mathematics teachers who participated in the STEAM-integrated PjBL model and those who followed conventional instruction.

Based on the results of the study, it is evident that there is a significant improvement in students' instructional management skills after the implementation of the PjBL–STEAM

learning model. The increase spans several aspects, including planning, implementation, evaluation, and reflective improvement. These findings confirm that integrating STEAM principles within project-based learning not only enriches learning experiences but also equips pre-service mathematics teachers with practical competencies essential for future instructional responsibilities. This aligns well with prior international research: for instance, (Chung et al., 2022) developed an iSTEAM PjBL model and found it effective in improving students' technological competence and engagement. Moreover, a study by (Diego-Mantecon et al., 2021) in ZDM, Mathematics Education revealed that STEAM-PBL can foster high cognitive demand and meaningful feedback loops in mathematics classrooms suggesting that such integrated models support both the depth of mathematical content learning and instructional quality.

The findings of this study also resonate with the argument put forward by (Siregar & Maysarah, 2025), who stated that STEAM-oriented learning models offer a strategic pathway for improving instructional practices in higher education. By combining multidisciplinary perspectives with hands-on project work, students are encouraged to think critically, collaborate effectively, and engage meaningfully in the learning process. This holistic approach becomes particularly relevant in teacher education, where students must be capable of designing and managing instructional activities independently.

Supporting evidence from previous research further strengthens the results of this study. (Sasmita & Harjono, 2021) showed that the application of project-based learning models can strengthen pupils' critical thinking skills, which are an essential component of learning management. Critical thinking enables future teachers to analyze learning challenges, choose appropriate strategies, and adapt instructional plans effectively. The improvement of this skill, as found in their study, aligns well with the increased performance demonstrated by students in the experimental group of this research.

Similarly, (Rajagukguk, 2023) found that the PjBL model can enhance students' creativity, which contributes to the development of learning management skills. (Kusuma, 2021) also emphasized that the PjBL model can strengthen the quality of students' communication, which is important in the context of learning management. The convergence of these findings supports the conclusion that integrating STEAM within the PjBL model provides a robust framework for developing comprehensive instructional management skills among pre-service mathematics teachers.

## CONCLUSION

In accordance with the result, it can be inferred that the implementation of the PjBL-STEAM model is effective in enhancing the learning management skills of prospective mathematics teachers. This is evidenced by the significant improvement in pretest–posttest scores in the experimental group compared to the control group. The improvement covers aspects of planning, implementation, evaluation, and reflection & revision, which reflect students' ability to design innovative instruction, apply project-based strategies, interpret evaluation results, and conduct reflection for future instructional improvement.

## ACKNOWLEDGMENT

This research was fully supported by the Directorate of Research and Community Service (DPPM), Ministry of Higher Education, Research, and Technology (Kemendiktisaintek) under contract number 130/C3/DT.05.00/PL/2025 dated May 28, 2025. The authors would like to express their highest appreciation to DPPM Kemendiktisaintek and LLDIKTI Region IX of South Sulawesi, West Sulawesi, and Southeast Sulawesi for the funding and facilities that made this study possible. Special thanks are also extended to the students, lecturers, and the academic community of STKIP Andi Matappa Pangkep for their active participation and valuable contributions throughout the research process.

## REFERENCES

Alimuddin, H., Abdullah, A., & Alam, A. Z. I. (2023). Efektifitas Modul Digital Berbasis STEAM Dilengkapi Animasi Flash untuk Pembelajaran Tematik pada Siswa Sekolah Dasar. *Jurnal Pelita: Jurnal Pembelajaran IPA Terpadu*, *3*(1), 45–56. https://doi.org/10.54065/pelita.3.1.2023.321

Ary, D., Jacobs, L., Irvine, C. S., & Walker, D. (2014). *Introduction to Research in Education* (9th ed.). Cengage Learning.

Budiyono, A., Luthfi, A., & Witarsa, R. (2023). Pengaruh Model Pembelajaran STEAM terhadap Kemampuan Sains dan Numerasi Siswa Madrasah Ibtidaiyah. *JIKAP PGSD: Jurnal Ilmiah Ilmu Kependidikan*, *7*(2).

Chung, C. C., Huang, S. L., Cheng, Y. M., & Lou, S. J. (2022). Using an iSTEAM project-based learning model for technology senior high school students: Design, development, and evaluation. *International Journal of Technology and Design Education*, *32*(2). https://doi.org/10.1007/s10798-020-09643-5

Denny, M., Denieffe, S., & O'Sullivan, K. (2023). Non-equivalent Control Group Pretest–Posttest Design in Social and Behavioral Research. In *The Cambridge Handbook of Research Methods and Statistics for the Social and Behavioral Sciences*. https://doi.org/10.1017/9781009010054.016

Diego-Mantecon, J. M., Prodromou, T., Lavicza, Z., Blanco, T. F., & Ortiz-Laso, Z. (2021). An attempt to evaluate STEAM project-based instruction from a school mathematics

perspective. *ZDM - Mathematics Education*, *53*(5). https://doi.org/10.1007/s11858-021-01303-9

Hikmawan, S. S. (2022). *Peningkatan Kemampuan Pemecahan Masalah Matematis dan Minat Belajar Matematika Siswa Sma Melalui Project-Based Learning Model dengan Pendekatan Steam (Pjbl-Steam)*. Universitas Pendidikan Indonesia.

Kusuma, Y. Y. (2021). Peningkatan Hasil Belajar SIswa dengan Menggunakan Model Pembelajaran Problem Based Learning di Sekolah Dasar. *Jurnal Basicedu*, *4*(4), 1460–1467. https://doi.org/10.31004/basicedu.v4i4.753

Paulina. (2020). *Penerapan model pembelajaran berbasis proyek (PjBL) untuk meningkatkan hasil belajar matematika siswa di SD Negeri 202 Anabanua Kabupaten Wajo*. Universitas Negeri Makassar.

Manjani, N., Syahrial, S., & Mailani, E. (2024). Perspektif Calon Guru Mengenai Tantangan Pembelajaran Matematika di Era Digital. *JGK (Jurnal Guru Kita)*, *8*(2), 237. https://doi.org/10.24114/jgk.v8i2.56722

Nada, Q., Pramasdyahsari, A. S., & Albab, I. U. (2023). Efektivitas Model Pembelajaran Project Based Learning STEAM Berbantuan Geogebra Terhadap Kemampuan Berpikir Kritis Siswa. *Jurnal Pendidikan Matematika Universitas Lampung*, *11*(2), 85–92. https://doi.org/10.23960/mtk/v11i2.pp85-92

Naufal, M. A., & Asdar, A. (2022). Investigasi Persepsi Mahasiswa Calon Guru Matematika Terhadap Penerapan Pembelajaran STEAM Di Sekolah. *Primatika : Jurnal Pendidikan Matematika*, *11*(2). https://doi.org/10.30872/primatika.v11i2.1221

Palennari, M., & Fauziyah, A. (2024). Pengaruh Model Project Based Learning (PjBL) berbasis Pendekatan Science, Technology, Engineering, Art, and Mathematic (STEAM) terhadap Hasil Belajar Kognitif Peserta Didik. *Seminar Nasional Hasil Penelitian*, 1953–1965. https://ojs.unm.ac.id/semnaslemlit/index

Rajagukguk, S. (2023). Penerapan Project Based Learning Untuk Meningkatkan Kreativitas Siswa SD. *ELEMENTARY: Jurnal Inovasi Pendidikan Dasar*, *3*(1). https://doi.org/10.51878/elementary.v3i1.1945

Rezkillah, I. I., Julaifah, N., Ramadhani, S., & Kasturi, K. (2024). Model Project- Based Learning Terintegrasi STEAM terhadap Kemampuan Pemecahan Masalah. *Jurnal Pendidikan Dan Pembelajaran Indonesia (JPPI)*, *4*(3), 1289–1295. https://doi.org/10.53299/jppi.v4i3.702

Safriana, S., Ginting, F. W., & Khairina, K. (2022). PENGARUH MODEL PROJECT BASED LEARNING BERBASIS STEAM TERHADAP KEMAMPUAN BERPIKIR KREATIF SISWA PADA MATERI ALAT- ALAT OPTIK DI SMA. *Jurnal Dedikasi Pendidikan*, *6*(1). https://doi.org/10.30601/dedikasi.v6i1.2315

Sani, R. A. (2020). *Metodologi Penelitian Pendidikan*. Bumi Aksara.

Santoso, E., Kurnia Sugandi, M., Warmi, A., & Galih Adirakasiwi, A. (2020). Mempersiapkan Calon Guru Matematika Dan Ipa Dalam Menghadapi Era Industri 4.0. *Jurnal Bio Educatio*, *5*(2), 50–55.

Sasmita, R. S., & Harjono, N. (2021). Efektivitas Model Problem Based Learning dan Problem Posing dalam Meningkatkan Kemampuan Berpikir Kritis Siswa Sekolah Dasar. *Jurnal Basicedu*, *5*(5). https://doi.org/10.31004/basicedu.v5i5.1313

Sugiyono. (2019). *Metode Penelitian Pendidikan: Pendekatan Kuantitatif, Kualitatif, dan R&D*. Alfabeta.