Project-based Model in Physics Learning: The Influence on Computational Thinking Skills on the Eleventh-Grade Natural Science Major Students

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Abstract. The low level of computational thinking skills of students is a problem of 21st-century skills. One of the efforts to support 21st-century education is by applying a Project-based learning model. This study aims to determine the effect of the application of a project-based learning model on the computational thinking skills of students in class XI IPA. The research was conducted at MA Al-Hikmah Bandar Lampung. The population in this study was XI IPA class with samples of XI IPA 1 (experimental class) and XI IPA (control class). Using saturated sampling technique with Quasi-Experimental Research design. The results of this study indicate that the t-test value with a significant level of 5% there is an effect of the project-based learning model on the computational thinking skills of students in class XI IPA with a sig value <0.05 which is equal to 0.000 then H0 is rejected and H1 is accepted. Therefore, computational thinking skills can be used to solve problems in physics learning by applying indicators of decomposition, abstraction, algorithms, and generalization of patterns.

1 Introduction

Globalization necessitates adaptation at all levels of society [1]. According to the OECD, people in the 21st century should be able to create new values. Furthermore, the Center for Curriculum Transformation (CCR) offers a comprehensive framework for embracing 21st-century education through four educational dimensions [2]. In the 2013 curriculum, learning is more focused on digital skills, creativity, communication skills, and innovation [3]. Many experts believe that problem-solving skills are essential for 21st-century education [4]. A person must process the problems they encounter in an appropriate sequence of solutions [5] and be capable of thinking structurally, creatively, and logically [6]. Computational thinking provides applications in a variety of sciences [7]. In recent years, computational thinking

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skills have been regarded as extremely important in learning [8] and have been widely accepted in many countries [9]. Learning and assessing 21st-century computational thinking skills remains extremely limited [10]. However, many countries have incorporated computational thinking into their educational curricula [11] i.e., the United Kingdom, Japan, Hong Kong, China, and Taiwan. They incorporate it into computer programming materials in the primary education curriculum. Malaysia has also implemented computational thinking in education since 2017 [12], The United States in 2016 [13]and Singapore [14], and countries that joined the European Union in 2016–2017. This demonstrates that computational thinking skills have been widely applied and adapted to new learning concepts in a variety of countries [10].

The low level of problem-solving is evidenced by the results of research observations conducted at MA Al-Hikmah Bandar Lampung and interviews with physics subject teachers, Mr. Iswahyudi, S.Si, who stated that learning activities employ conventional models, causing students to become bored and have difficulty learning physics. He also stated that the eleventh-grade Natural Science major students' problem-solving skills have yet to be fully developed. Pre-research data revealed that students' computational thinking skills remain low. This data was supported by questionnaires to test students' attitudes toward problem-solving, which remain relatively low. This finding is consistent with the lack of study on computational thinking in Indonesia, which has resulted in few implementations of computational thinking instruction in schools [1]. In Indonesia, computational thinking is inextricably linked to information technology and computer science [15], officially mentioned in the addendum to the Regulation of the Ministry of Education and Culture (Permendikbud) No. 37 [13]. Computational thinking among Indonesian students needs to be enhanced because it is currently lacking [16] and the government should consider making computational thinking a compulsory topic in schools [12].

One of the learning models chosen for implementation is the project-based learning model, which can significantly increase 21st-century skills by integrating students directly into project assignments [17]. Furthermore, project-based learning is regarded as one of the most promising learning models in science education, with the potential to improve science process skills [18] which students are encouraged to be more active, creative, and constantly instructed to solve problems and make their judgments [19].

Several more studies investigated the use of project-based learning models on computational thinking skills [9], the application of project-based learning in computational thinking skills activities using Matlab [5], project-based programming learning to develop computational thinking skills [8], the development of project-based models, Project-based robotic learning for computational thinking skills [20], and computational thinking skills practice via modeling [7].

Although there have been numerous studies done to increase computational thinking skills, the project-based learning model for computational thinking in the eleventh-grade Natural Science major has never been applied to physics lessons. The goal of this study is to investigate the influence of the adoption of a project-based learning model on computational thinking Skills.

2 Research Methods

The method employed was quasi-experimental research with a quantitative approach using the Non-equivalent Control Group Design. This research was carried out at MA Al-Hikmah Bandar Lampung. The population consisted of 60 eleventh-grade Natural Science Major students. The sampling technique utilized was the saturated sampling technique [21], with class XI IPA 1 as an experimental class (the class that received project-based learning model treatment) and class XI IPA 2 as a control class (the class that received problem-based learning model treatment) of 30 participants each. Figure 1 and Table 1 show the research design:

Table 1. Quasi-experimental Design

Pretest	Treatment	Posttest
O_1	X	O_2
O_3	C	O_4

The experimental and control classes were initially given a pretest to determine the initial ability [21,22] and After being treated, students were given posttests on computational thinking skills that had been evaluated for feasibility using validity tests, reliability tests, level of difficulty tests, and discriminant tests. Figure 1 shows the research technique for determining students' computational thinking skills:

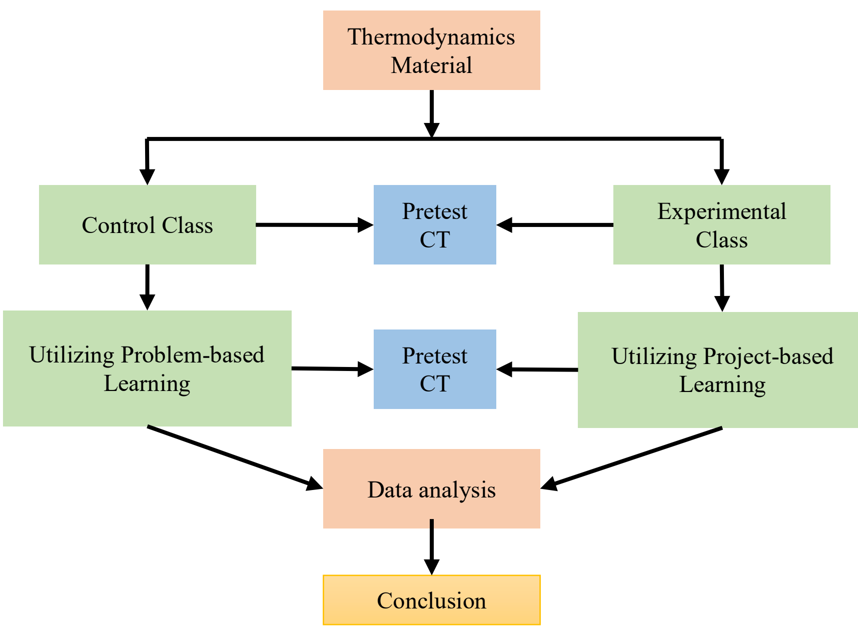

Fig. 1. Research Flowchart

The following instruments were employed in this study: a computational thinking skills essay test, documentation, and an observation sheet for the project-based model implementation. Documentation and observation sheets were utilized to collect qualitative data during the learning process, while the essay test was used to quantitatively assess the progress of students' computational thinking skills.

This study employed the N-Gain test, the Kolmogorov-Smirnov normality test, the Levene test for homogeneity, and the t-test for hypothesis testing. The test can be applied if the data being investigated is normally distributed and homogeneous[23]. The t-test was calculated using SPSS version 24, with a level of significance of 0.05.

2.1 N-gain Test

The formula to see the gain score is as follows [24]:

$$gain = (posttest \text{ score}) - (pretest \text{ score}) \quad (1)$$

The formula to see the N-gain score is as follows [25]:

$$N - gain\ (g) = \frac{posttest\ score - pretest\ score}{maximum\ score - pretest\ score} \quad (2)$$

Table 2. N-gain Interpretation

Gain	Interpretation
$g \geq 0{,}7$	High
$0{,}3 \leq g < 0{,}7$	Moderate
$g < 0{,}3$	Low

2.2 Normality Test

The normality test was performed using the Kolmogorov – Smirnov formula [26]
- If the Significance value is higher than 0,05, Ho is rejected and H1 is accepted, which means that the sample comes from a normally distributed population.
- If the Significance value is lower than 0,05, Ho is accepted and H1 is rejected, which means that the sample does not come from a normally distributed population.

Table 3. Normality Test Interpretation

Probability	**Description**	Interpretation
$Sig > 0{,}05$	H_0 is rejected	Data is normally distributed
$Sig < 0{,}05$	H_0 is accepted	Data is not normally distributed

2.3 Homogeneity Test

The Levene test was performed to test the homogeneity of variances of several populations. Using a one-way analysis of variance, the data was transformed by finding the difference between each score and the group average [27]. The hypothesis test is as follows:

$H0 : \sigma 1^2 = \sigma 2^2$

$H1 : \sigma 1^2 \neq \sigma 2^2$

- Determine the level of significance $\alpha = 0{,}05$
- Determine the critical value, namely the area where H_0 is rejected if $W > F(\alpha;k\text{-}1,n\text{-}k)$
- Determine the test statistic:

$$W = \frac{(n-k)\sum_{i}^{k} = 1ni(\overline{z_l} - \bar{z})^2}{(k-1)\sum_{i=1}^{k}(z_{ij} - \acute{z}i)^2}$$

- Determine the criteria for testing H_0:

Table 4. Homogeneity Test

Probability	Description
$Sig > 0{,}05$	Homogeneous
$Sig < 0{,}05$	Not homogeneous

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2.4 Hypothesis Test

After the research data is known to be normally distributed and has a homogeneous variance, a t-test is carried out with a significant level of α = 0.05. Here is the formula:

$$t_{observed} = \frac{\overline{x_1} - \overline{x_2}}{s_{gab}\sqrt{\frac{1}{n_1} + \frac{1}{n_2}}}$$

$$s_{gab} = \sqrt{\frac{(n_1 - 1)s_{1^2} + (n_2 - 1)s_{2^2}}{n_1 + n_2 - 2}}$$

And degrees of freedom (d_k) = $\boldsymbol{n_1 + n_2 - 2}$,
Description:
$\overline{x_1}$= Average score of physics learning outcomes of experimental class students
$\overline{x_2}$= average score of physics learning outcomes of control class students
n_1 = Number of experimental class samples
n_2 = Number of control class samples
s_{12} = Experimental class variance
s_{22} = Control class variance
S = pooled standard deviation [28].
The provisions of the t-test in this study are as follows:
If Sig > 0,05, then H_0 is accepted and H1 is rejected
If Sig ≤ 0,05, then H1 is accepted and H0 is rejected
Description:
H0 = There is no effect of the PjBL model on *Computational Thinking* ability.
H1 = There is an effect of the PjBL model on *Computational Thinking* ability. [29]

3 Result and Discussion

The pretest and posttest scores in the experimental class and control class can be seen in Table 5 and Figure 3.

Table 5. The Results of Pretest, Posttest, and N-Gain

No.	Class	Average Pretest Score	Average Posttest Score	Average N-Gain Score	N-Gain Interpretation
1.	Experimental	69,80	78,67	0,285	Moderate
2.	Control	67,80	74,97	0,219	Low

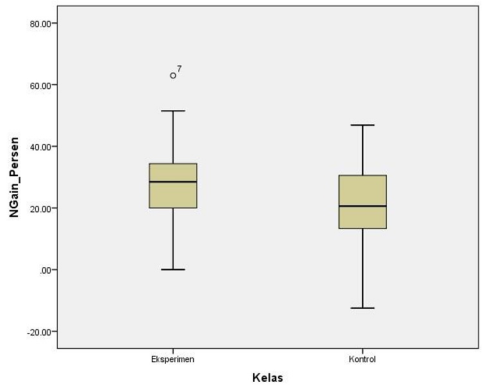
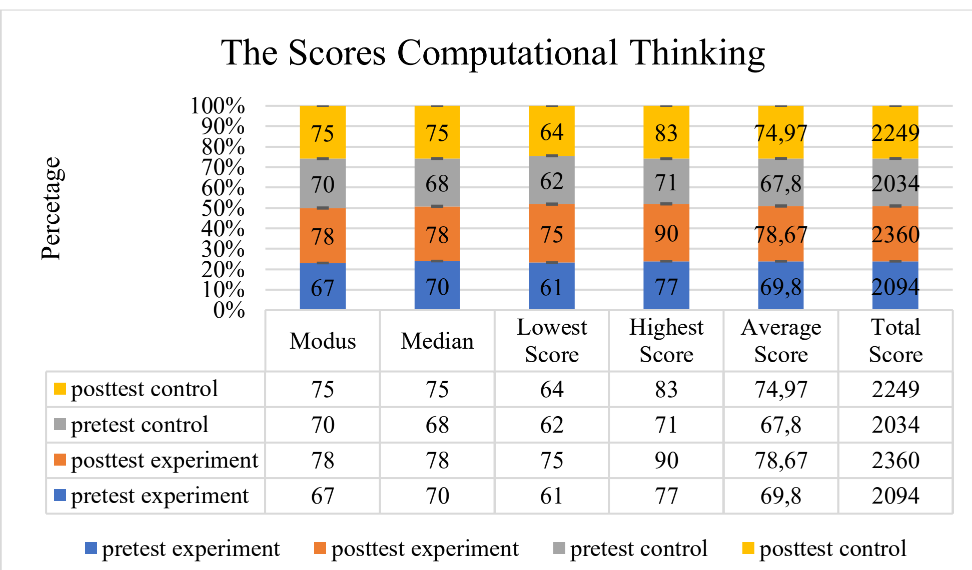


Fig. 3. N-Gain Value Percentage

According to the calculation results, there are differences between the experimental class's pretest and posttest outcomes and the control class. The average Ngain percent value for the experimental class was 0.285, whereas for the control class, it was 0.219. The average pretest score in the experimental class was 69.80, while in the control class it was 67.80. The average posttest value in the experimental class was 78.67, while in the control class, it was 74.97. This demonstrates that the pretest and posttest scores in the experimental class are greater than those in the control class. The results of computational thinking skills can also be displayed in the form of a bar chart graph shown in Figure 4 below:



	Modus	Median	Lowest Score	Highest Score	Average Score	Total Score
posttest control	75	75	64	83	74,97	2249
pretest control	70	68	62	71	67,8	2034
posttest experiment	78	78	75	90	78,67	2360
pretest experiment	67	70	61	77	69,8	2094

Fig. 4. The Pretest dan Posttest Scores

Based on the data analysis, it is clear that the average pretest results of the computational thinking ability of experimental and control class students are poor, which is because neither the control nor the experimental classes examined the content under consideration. Another factor that distinguishes students' computational thinking skills is that both the experimental and control classes use the same physics teacher's teaching technique. The researchers also used the observation sheet for learning model implementation to assess the learning process. Table 6 shows the following percentages:

Table 6. PjBL Observation Sheet

Meeting	**Observation Score**	**Percentage**	**Category**
1	11	100%	Excellent
2	11	100%	Excellent
3	11	100%	Excellent

Based on the analysis of the observation sheet, it was discovered that the results of the implementation of the project-based learning model at the first meeting obtained a percentage value of 100% in the excellent category. At the second meeting, a percentage value of 100% was obtained in the excellent category. At the third meeting, a percentage value of 100% was obtained in the excellent category. The average percentage of observation scores is 100%, implying that the project-based learning model was successfully implemented in the teaching process in the experimental class. Table 7 shows the processes for applying the project-based learning model to computational thinking skills in the experimental class.

Table 7. Storyboard of the PjBL-CT Model Implementation

PjBL Syntax	Activity Description	**CT Indicator**	**Image**
Opening	The teacher asks questions about the material to be learned. Students answer questions that they know.	Abstraction	
Project's Design Formulation	Students elaborate on the given problem by designing a project that will be made.	Decomposition	
Project's Schedule	Students are given time to determine how long it will take for the project to be completed.	Algorithm	

PjBL Syntax	Activity Description	**CT Indicator**	**Image**
Project Monitoring	The teacher monitors students making projects while understanding the process related to the material learned.	Abstraction	
Project Assessment	Students present the results of the project by testing the project then they begin to collect the results of the discussion based on the theory and the project.	Pattern Generalization	
Evaluation	Teachers and students evaluate the results of the project work made, then conclude and also reflect on the learning activities carried out.	Abstraction	

The storyboard above illustrates how the project-based learning model allows learners to gain abilities. At the start of each meeting, the teacher asks basic questions about the material being covered. The question is one of the motives provided by the teacher to students to solve difficulties that develop. This activity is designed to train learners to think by applying computational thinking abilities following the components used, such as abstraction or the approach used to retrieve crucial information in an issue that emerges.

Furthermore, learners can create projects that will be built. This level teaches students how to express their simple problems using decomposition techniques. In this model, learners are also given the option to choose the timeline for the project until it is done. This level provides learners with algorithmic abilities, or the ability to execute assignments in the form of projects in a methodical and structured manner.

Following that, pupils grasp the process of creating projects based on the subject being studied. This stage gives students abstraction skills. Another computational thinking talent is the generalization pattern, which is applied when students test their work. At this point, students use their projects to draw together the findings of the theoretical discussion. Furthermore, learners form inferences and reflect on learning activities, which encourages them to use reasoning or abstraction skills. Figure 5 is an example of computational thinking skills inquiries about the substance of the law of thermodynamics employed in the investigation [30].

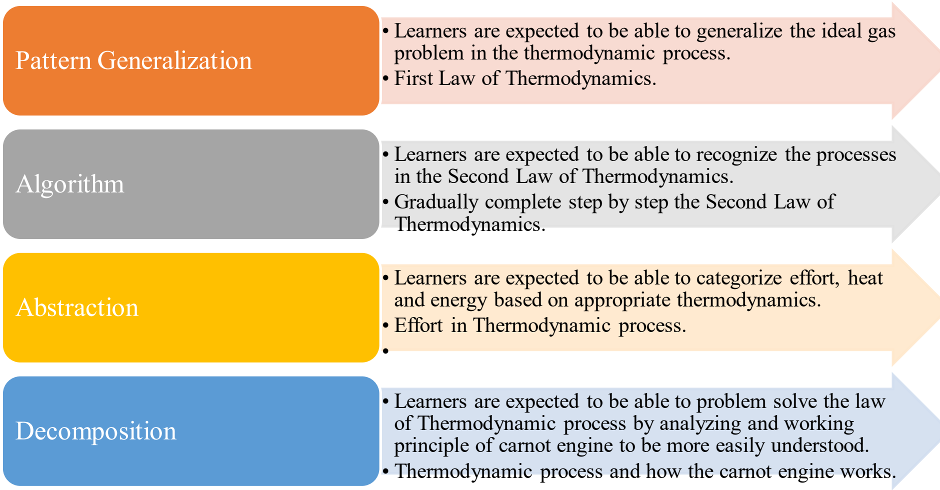


Fig. 5. Computational Thinking Skills Indicators

The results of the research may be observed in the posttest normality test, which yielded a value of 0.069 in the control group and 0.188 in the experimental group. As a result, if the normality value is at a significant level of 5% or 0.05, Ho is accepted. This result signifies that the pretest-posttest findings from the control and experimental classes exceeded the normality criterion, implying that the two research samples were drawn from a normally distributed population. The posttest homogeneity in the control and experimental classes was calculated using the Levene test with a significant level of 5% or 0.05 in the experimental and control classes, yielding a value of 0.400. As a result, we can conclude that the two samples employed in this investigation are homogeneous. Tables 8 and 9 present the results of the normality and homogeneity tests.

Table 8. Normality Test Result

Group		**Significance**	**Description**
Control	*Pretest*	0,123	Normal
	Posttest	0,069	Normal
Experimental	*Pretest*	0,200	Normal
	Posttest	0,188	Normal

Table 9. Homogeneity

Group	**Significance**	**Description**
Experimental	0,400	Homogeneous
Control		

The above data from both class groups are normally distributed and homogeneous, so the next step is to test the hypothesis with the Independent Samples t-test. Table 10 presents the t-test results:

Table 10. Independent Sample T-test Result

Learning Outcomes	**f**	**Sig. (2-tailed)**	**t**	**df**
Equal Variances assumed	.718	.000	4.057	58
Equal Variances not assumed		.000	4.057	57.090

The t-test findings show the significant value is less than 0.05 (0.000), indicating that H0 is rejected and H1 is accepted. This finding implies that there is a relationship between the experimental class using the project-based learning model and the control class using the problem-based learning model. This finding is consistent with previous research, which claims that the study was conducted utilizing a quasi-experimental design with assessment instruments in the form of pretests and posttests with varying results. The control class's initial post-test results showed that the guided teaching model was less effective than the project-based learning model. Students who implement this approach respond positively, and they are excited about strengthening their computational thinking abilities [9].

According to Azmi and Ummah's research, there was a considerable increase in student scores before and after the activity by 22.83%. Programming interest also increased, however not dramatically by 8%. After the activity, students Scratch skills improved by 71%. At this percentage, the teacher considers that this practice is sufficient to introduce Scratch to students. Thus, the enthusiasm assessment yielded a score of 88.00%, indicating that students like learning. Finally, 87% satisfaction indicates that activities are being implemented successfully and satisfactorily [5].

According to Francesca Bertacchini et al.'s research, project-based learning works and proves to be an effective and very interesting learning method. It can motivate students to find ways to program in new ways through the development of critical thinking and problem-solving skills [31]. According to Aslina's research, the use of the Project-based Learning model promotes the integration of computational thinking skills into real-world project experiences. Students are successful in PBL-CT software development and testing, as evidenced by survey results after completing the course, management and communication significantly improved. This project strengthens students' reasoning and thinking skills through problem-solving tasks such as project planning, modeling, system design, development, and execution [9].

The present research concludes that the learning process through project activities has trained students' creativity to increase problem-solving skills. Students become more active and creative in their learning when they are expected to understand and solve their problems through project activities. At the end of the learning process, students must give project assignments to determine the relationship between physics ideas and the projects they create. Overall, the experimental class demonstrated superior problem-solving skills than before.

The project-based learning model can help students to be directly involved in the learning process because they must be more active and creative to find out the solution to the problems that have been given by the teacher. Students are always faced with projects that must be completed and connected with the physics concepts they are learning. Thus, their level of problem-solving increases because they are given many opportunities to explore their skills. The disadvantage of this study is that it does not assess computational thinking skills across all indicators. The samples only implemented abstraction, decomposition, algorithm, and generalization skills in the thermodynamics material.

4. Conclusion

Based on the research findings and data analysis, it is possible to conclude that the implementation of the project-based learning model affects the computational thinking skills of students in class XI IPA at MA Al-Hikmah Bandar Lampung. The results of data analysis for hypothesis testing show that if Sig is higher than 0.05, H_0 is accepted and H_1 is rejected, but if Sig is lower than 0.05, H_1 is accepted and H_0 is rejected. The t-test hypothesis test resulted in a significant value of less than 0.05 (0.000), indicating that H0 is rejected and H1 is accepted. It means that there is an influence of the project-based learning model on the computational thinking skills of the eleventh-grade science students at MA Al-Hikmah Bandar Lampung on the material of the law of thermodynamics.

Future research can apply the same learning model to measure students' computational thinking skills using appropriate learning models with different materials and can test computational thinking skills on all indicators, namely decomposition, abstraction, algorithms, pattern generalization, and evaluation, and pay attention to the allocation of classroom time because this research takes a relatively long time.

References

1. M. Ansori, Dirasah J. Stud. Ilmu Dan Manaj. Pendidik. Islam **3**, 111 (2020)
2. M. Bialik and C. Fadel, Cent. Curric. Redesign **3**, 29 (2015)
3. Y. Yunita, D. Juandi, Y. S. Kusumah, and S. Suhendra, J. Phys. Conf. Ser. **1882**, 012080 (2021)
4. G. S. N. Adi Mulyanto, Yasya Rusyida, Book 1 (2020)
5. R. D. Azmi and S. K. Ummah, J. Pendidik. Mat. (JUDIKA Educ. **4**, 34 (2021)
6. B. Zhong, Q. Wang, J. Chen, and Y. Li, J. Educ. Comput. Res. **53**, 562 (2016)
7. N. Shin, J. Bowers, J. Krajcik, and D. Damelin, Discip. Interdiscip. Sci. Educ. Res. **3**, 7 (2021)
8. A. Nurhopipah, I. A. Nugroho, and J. Suhaman, J. Pengabdi. Kpd. Masy. **27**, 6 (2021)
9. A. Saad and S. Zainudin, Learn. Motiv. **78**, 101802 (2022)
10. S. Grover and R. Pea, Educ. Res. **42**, 38 (2013)
11. C. Tikva and E. Tambouris, Comput. Educ. **162**, 104083 (2021)
12. H. Kuswanto, N. Rodiyanti, Y. N. Kholisho, and B. D. D. Arianti, Educatio **15**, 78 (2020)
13. M. Z. Zahid, N. R. Dewi, T. S. N. Asih, E. R. Winarti, T. U. K. Putri, and B. E. Susilo, in *Prism. Pros. Semin. Nas. Mat.* (2021), pp. 476–486
14. H.-J. So, M. S.-Y. Jong, and C.-C. Liu, Asia-Pacific Educ. Res. **29**, 1 (2020)
15. W. N. Hidayat, M. Muladi, and M. A. Mizar, J. Pendidik. Teor. Penelitian, Dan Pengemb. **1**, 2281 (2016)
16. M. A. S. Sulistiyo and A. Wijaya, J. Phys. Conf. Ser. **1581**, 012046 (2020)
17. J. Educ. Online **19**, (2022)
18. A. Fitriyah and S. D. Ramadani, J. Educ. **3**, 7 (2021)
19. S. Achappa, L. R. Patil, V. S. Hombalimath, and A. R. Shet, J. Eng. Educ. Transform. **33**, 247 (2020)
20. B. Díaz-Lauzurica and D. Moreno-Salinas, Sustainability **11**, 5109 (2019)
21. Sugiyono, *Metode Penelitian Pendidikan Kantitatif, Kualitatif, Kombinasi, R&D Dan Penelitian Tindakan* (Alfabeta, Bandung, 2019)
22. D. Suryana, *Pengantar Statistika Pendidikan* (CV Budi Utama, Yogyakarta, 2018)
23. Yuberti and A. Saregar, *Pengantar Metodologi Penelitian Pendidikan Matematika Dan Sains* (Aura, Lampung, 2017)
24. R. Ramadhani and A. Amudi, AKSIOMA J. Progr. Stud. Pendidik. Mat. **9**, 64

(2020)
25. C. Y. Eviyanti, E. Surya, E. Syahputra, and M. Simbolon, Int. J. Nov. Res. Educ. Learn. **4**, 138 (2017)
26. A. Saregar, S. Latifah, and M. Sari, J. Ilm. Pendidik. Fis. Al-Biruni **5**, 233 (2016)
27. U. Usmadi, Inov. Pendidik. **7**, (2020)
28. H. R. Sundayana, (2018)
29. A. Yudhira, VALUE **2**, 1 (2021)
30. Y. Yin, R. Hadad, X. Tang, and Q. Lin, J. Sci. Educ. Technol. (2019)
31. F. Bertacchini, C. Scuro, P. Pantano, and E. Bilotta, Front. Robot. AI **9**, (2022)