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STEAM Learning Training Based on Robot for Mission (R4M) Coding to Support 21st Century Thinking Skills

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Abstract: The Community Empowerment Partnership Program (PKM) implemented at SMA Negeri 1 Ambon aims to support the improvement of 21st century skills through Science, Technology, Engineering, Art, and Mathematics (STEAM) learning training based on Coding Robot For Mission (R4M). This program was initiated in response to the challenges of digital era education, which demands critical thinking, problem solving, collaboration, and communication skills, both to prepare students for the global workforce and to promote the advancement of the Maluku region. The implementation of activities was based on the results of an analysis of the situation and the needs of partners, which were then agreed upon jointly. The method used is Community Development, which is an empowerment and partnership-based approach, actively involving the school community in every stage of the activity, from socialization, module development, coding, and robotics design training, to technology implementation assistance. The results of this program show that SMA Negeri 1 Ambon, as a partner, has great potential as a pioneer in the application of STEAM-based learning and digital literacy, but still faces significant limitations. Nevertheless, teachers and school officials show high enthusiasm and readiness for change. With the support of training, mentoring, and the provision of facilities, SMA Negeri 1 Ambon has the potential to become a model for the implementation of STEAM and coding in Maluku Province, while also strengthening students' 21st-century skills in a sustainable manner.

Keywords: STEAM Learning, Coding, Robotics, R4M, Thinking Skills.

Introduction

Education in Maluku Province is currently confronted with significant challenges in optimizing technological literacy amid the digital transformation era, characterized by the emergence of automation, artificial intelligence, and the Internet of Things (IoT) (Barus et al., 2025)Within the context of twenty-first-century education, the imperative to equip students with critical competencies—such as analytical thinking, complex problem-solving, collaboration, and effective communication—has become increasingly urgent (Diocos, 2023; Kuloğlu & Karabekmez, 2022). These competencies are not only essential for individual success in the global labor market but also serve as a strategic foundation for regional advancement, particularly for regions such as Maluku, to enhance competitiveness in the development of technology based on local resources (Hermansyah, 2020). In response to these demands, one pedagogical approach that may be effectively implemented is the Science, Technology, Engineering, Arts, and Mathematics (STEAM)–based learning approach.

The STEAM approach constitutes an instructional framework that integrates multiple disciplines into a unified learning process grounded in creativity and innovation (Roshayanti et al., 2022). In Indonesia, the STEAM approach has begun to be implemented across educational levels, ranging from elementary to senior high school (Pramudyani & Indratno, 2022). This approach has the potential to bridge the demands of

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twenty-first-century education with the contextual challenges faced by students in Maluku Province.

Through the integration of science, technology, engineering, arts, and mathematics, students are expected not only to comprehend theoretical concepts but also to apply them in the form of tangible projects that generate meaningful benefits for their surrounding environment. For instance, such projects may include the development of water quality monitoring systems for coastal areas, simple renewable energy prototypes, or the design of sensor-based assistive devices tailored to the needs of archipelagic communities. These initiatives require foundational competencies in programming (coding), technological design, and robotics programming.

Furthermore, STEAM-based learning serves as an effective medium for fostering innovation, creativity, and technology-oriented entrepreneurial mindsets among students. These competencies are critically important in addressing regional development challenges and in creating new economic opportunities grounded in creative industries and appropriate technology within Maluku Province.

Figure 1. The building of SMA Negeri 1 Ambon, located on Pattimura Street, Ambon City

SMA Negeri 1 Ambon is one of the leading secondary schools located at Pattimura Street No. 28, Sirimau District, Ambon City, Maluku Province. As a flagship institution, the school holds strategic potential to lead the transformation from conventional instructional practices toward an integrated STEAM-based learning model incorporating coding and robotics. The school offers two academic streams—Natural Sciences (IPA) and Social Sciences (IPS)—with a total student enrollment of 1,568 students in the 2024/2025 academic year.

Figure 2. Meeting with the School Principal

Although SMA Negeri 1 Ambon is recognized as a leading school, findings from observations and discussions with school representatives indicate that the institution still faces limitations in facilities and infrastructure supporting technology-based practicum activities. Practical sessions are currently confined to the Natural Sciences subject group. To date, the school does not yet have a dedicated laboratory to optimally support coding and robotics practice. The available facilities remain limited to standard computer units, and there is an absence of supporting equipment such as basic robotics kits, which restricts students' opportunities to engage in applied experimentation. In fact, such kits constitute essential components in training students to enhance their coding competencies and robotic technology design skills.

Figure 3. (a) Natural Sciences Laboratory Facilities; (b) Computer Laboratory

As a consequence of this condition, students' experiential learning in applying STEAM concepts in a practical context remains relatively limited. This is reflected in the suboptimal mastery of 21st-century skills, particularly in aspects of computational thinking, technology-based problem solving, and collaboration in innovative projects. These competencies are essential to ensure that graduates of SMA Negeri 1 Ambon are able to compete in the digital era and contribute to the development of technology-based solutions addressing local needs in Maluku.

As a strategic response, it is necessary to strengthen laboratory facilities through the provision of practicum equipment integrated with digital technology, particularly coding-based and introductory robotic technology design tools. The availability of such devices would enable students to engage in in-depth exploration of prototype development that integrates principles of physics, mathematics, and computer science within an innovative and cohesive learning process.

In addition, enhancing teachers' capacity in utilizing these technologies should be prioritized. Teachers need to be equipped with fundamental training in coding and basic robotic technology design using the Gigo S4A (Scratch for Arduino) Programming Bricks. Through the Community Partnership Empowerment Program (PKM), it is expected that teachers will be able to effectively transfer knowledge and skills to students, thereby fostering the development of 21st-century thinking skills through the implementation of STEAM-based learning integrated with Coding Robot for Mission (R4M).

Method

The PKM activities were conducted in three main stages: (1) activity implementation; (2) partner participation; and (3) program evaluation. During the activity implementation stage, the activities were carried out based on an analysis of the situational problems, the partners' needs, and the jointly agreed solutions(Balaka, 2022). In practice, the implementation employed a problem-solving stage design for the partners, which is illustrated in Figure 4 below.

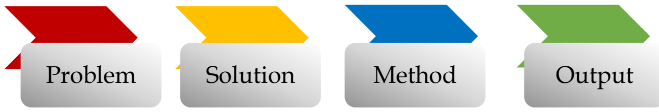

Figure 4. Partner Problem-Solving Stage Design

Each stage in the partner problem-solving process considers two aspects: the social-community aspect and the management aspect. To facilitate implementation, the PKM approach employed is the Community Development method, which emphasizes the empowerment of community partnerships. In this context, the community plays an active role both as an agent and as a beneficiary of development, and is involved directly in each stage of the community service activities to be carried out. The PKM activities were conducted over a period of eight months, from January to August 2025, and were divided into five stages: (1) socialization; (2) preparation for robotic design; (3) development of robotic coding modules; (4) training in coding and robotic design; and (5) mentoring on the application of coding and robotic design technologies.

The partner in this PKM activity was SMA Negeri 1 Ambon, involving teachers from various academic disciplines. Partner involvement or participation is a key factor in the successful implementation of PKM activities. The extent of partner participation in this PKM program is presented in Table 1 below.

Table 1. Partner Participation in the Implementation of the PKM Program Activities

Partner Name	Activities Involving the Partner
SMA Negeri 1 Ambon	▪ Assisted the PKM team in providing venues for socialization activities and mentoring in the application of technology. ▪ Assisted the PKM team in preparing teachers of Mathematics, Physics, Chemistry, and Biology as participants in technical training conducted by the PKM implementation team. ▪ Applied the training outcomes by conducting STEAM-based learning within the school environment. ▪ Collaborated with the PKM implementation team to carry out evaluations of STEAM learning activities. ▪ Committed to maintaining and taking care of the STEAM R4M learning and practicum tools received as educational resources.

The final stage in implementing the PKM activities is the evaluation phase. This phase aims to determine the extent to which the PKM activities have been successfully carried out.

a. Evaluation of Robotic Practicum Module Development: The completed modules were evaluated by experts using evaluation sheets as assessment instruments. The evaluation process assessed aspects including the module's layout, content, and language of presentation.
b. Evaluation of the Module: This includes assessment of the module's layout, content, and language of presentation.

c. Evaluation of Coding and Robotic Design Training: This evaluation is conducted by administering pre-tests and post-tests to the teachers using test questions as instruments. The purpose is to determine the extent to which the training material is understood by the teachers, both before and after the PKM activities.
d. Evaluation of PKM Program Implementation: This evaluation is carried out by distributing questionnaires to the teachers via Google Forms. The purpose is to identify shortcomings during the training and mentoring activities. The evaluation is expected to provide useful feedback for the implementation team to address deficiencies and improve the quality of PKM activities in subsequent cycles

Results and Discussion

The results and discussion of the PKM implementation process for teachers at SMA Negeri 1 Ambon can be explained based on the stages of PKM implementation and the evaluation activities, which are described as follows.

Socialization

The initial stage of the PKM program began with a meeting with the partners to establish a shared understanding of the program plan, including its objectives, schedule, and types of activities to be carried out at the school. In addition to presenting the plan, the team collected various suggestions and needs from the school, particularly regarding the use of robotic kits and strategies for implementing STEAM-based learning at SMA Negeri 1 Ambon.

Figure 5. Socialization Activity with the Principal of SMA Negeri 1 Ambon

ROBOTIC Design Preparation

After the socialization activities were completed, the next step taken by the PKM team was to identify the components of the Gigo S4A Programming Bricks kit, particularly the Arduino Leonardo as the central controller, and to study the connection diagrams for the Arduino. This step is crucial to ensure that each component can be used according to its intended function.

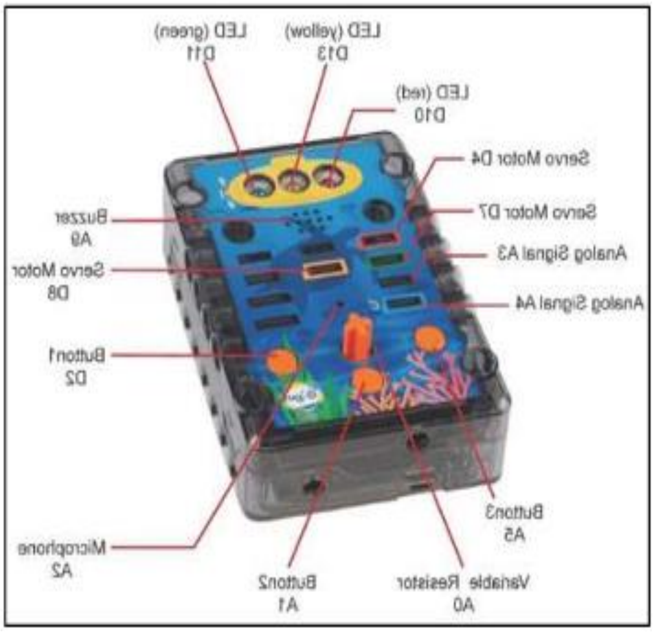

Figure 6. Components of the Gigo Maker Controller

Species	Pin	Species	Pin
Variable resistor	A0	Microphone	A2
Button1	D2	Servo Motor	D4/ D7/ D8
Button2	A1	Buzzer	A9
Button3	A5	LED (red)	D10
Analog Signal	A3	LED (green)	D11
Analog Signal	A4	LED (yellow)	D13

Figure 7. Connection Diagram to S4A

The next stage involved designing and assembling the robot by utilizing various components from the kit, such as motors, wheels, wires, and sensors. The design process was carried out to ensure that the constructed robot is relevant to cross-curricular learning needs, including Mathematics, Physics, Chemistry, and Biology.

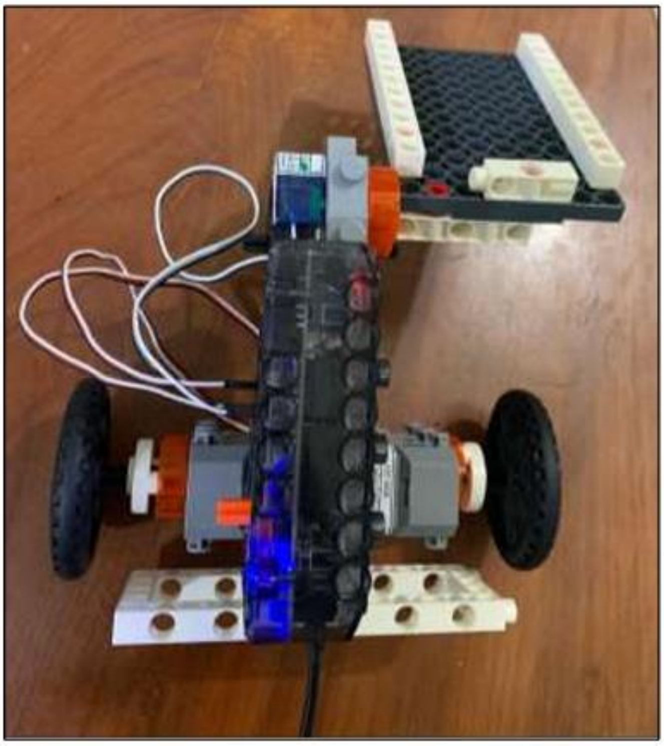

Figure 8. Simple Robot Design

The final stage involved creating sample code to connect the hardware components with commands executed in the S4A application. This program enables the robot to perform movements according to instructions, such as moving forward, backward, turning right, and turning left. Through this simple coding, students can directly observe how digital commands control the robot's movements.

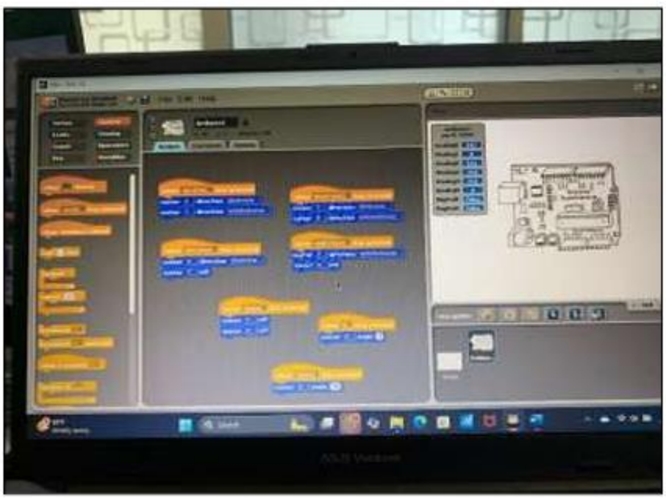

Figure 9. Robot Coding in the S4A Application

Robotic Coding Module Development

The robotic coding module that was successfully developed contains materials ranging from the introduction to basic coding principles to the step-by-step instructions for operating the assembled robotic devices. The designed robotic coding module is shown in Figure 10 below.

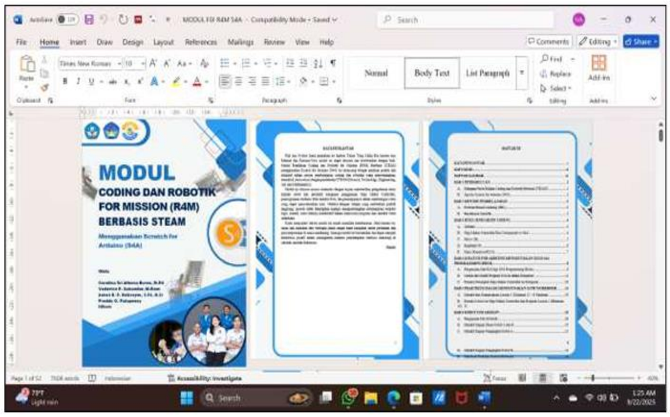

Figure 10. STEAM-Based Coding and Robotic for Mission (R4M) Module

This module was developed to assist the PKM partner, SMA Negeri 1 Ambon, in implementing STEAM-based learning using robotic coding. In addition, the module serves as a practical guide for teachers, helping them to understand and teach robotic coding more easily and in a structured manner.

Coding and Robotic Design Training

The coding and robotic design training was conducted on July 22–23, 2025, and was attended by 19 teachers from the Science and Mathematics (MIPA) disciplines. The training was carried out in two stages. On the first day (July 22, 2025), participants were introduced to STEAM concepts, Robotic for Mission (R4M), basic coding principles, and the use of Scratch for Arduino (S4A). On the second day (July 23, 2025), the training continued with hands-on activities, including designing robots, creating code to control robot movements (forward, backward, turn right, and turn left), and testing the robot's speed and accuracy in completing mission-based tasks, such as robotic competitions.

On the first day, the activities began with the administration of a preliminary questionnaire to map the teachers' understanding of the STEAM approach and coding. The results indicated that most teachers already had a fairly good conceptual understanding. Specifically, 84.2% of the teachers correctly identified STEAM as the integration of Science, Technology, Engineering, Arts, and Mathematics. However, 10.5% of the teachers believed that STEAM only encompasses Science and Technology, and 5.3% equated it with a combination of Arts and Physical Education.

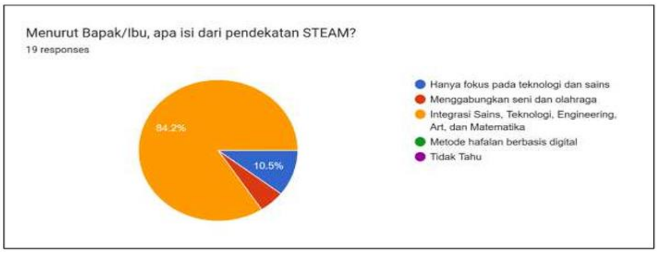

Figure 11. Teachers' Knowledge of the STEAM Approach Components

Following the preliminary questionnaire, the activities continued with the delivery of three core materials. The first material focused on Deep Learning in STEAM, emphasizing the importance of integrating Science, Technology, Engineering, Arts, and Mathematics in the learning process. Teachers were introduced to project-based learning principles, 21st-century skills (critical thinking, creativity, collaboration, and communication), and strategies for connecting theoretical concepts with real-world classroom practice.

Figure 12. Delivery of Deep Learning in STEAM Material

The second material covered Robotic for Mission (R4M), basic coding, and its application in learning. In this session, teachers were introduced to the concept of robotics as a learning medium that promotes problem-solving, creativity, and collaboration. The instructor explained how R4M can be applied through mission-based learning scenarios, such as programming robots to automatically turn on a light or follow a designated path.

Figure 13. Delivery of Robotic for Mission and Basic Coding Material

The third material focused on the use of Scratch for Arduino (S4A). Teachers were shown the S4A interface, how to assemble code blocks, and examples of simple instructions to control robot movements. This visual approach was designed to help teachers understand that coding can be learned easily and progressively. By mastering S4A, teachers are expected to guide students in designing simple robotic projects.

Figure 14. Delivery of Scratch for Arduino (S4A) Usage Material

Although teachers demonstrated a fairly good theoretical understanding of STEAM, the questionnaire also revealed a significant gap between knowledge and practical experience. Specifically, 78.9% of teachers reported that they had never designed or implemented STEAM-based learning, 15.8% had only observed examples from others, and 5.3% had tried it but were not confident in the results. No teachers reported routinely applying STEAM in their teaching. This indicates that the majority of teachers still rely on conventional, teacher-centered instructional methods.

Figure 15. Teachers' Experience in Designing or Implementing STEAM-Based Learning

The issue became even clearer when the questionnaire addressed teachers' understanding of coding. A total of 21.1% of teachers admitted to having no knowledge of coding at all, 63.2% had only heard the term but did not understand its essence, and only 15.8% had a basic understanding of the concept. Furthermore, no teachers had ever attempted to use a coding application or teach it to students. These findings highlight that teachers' digital literacy remains very low, despite the importance of coding skills in developing students' computational thinking abilities in the digital era.

Figure 16. Teachers' Understanding of Coding

On the second day, the training activities focused on hands-on practice in designing and operating robots using the Gigo S4A kit. Teachers were divided into groups to assemble simple robots and then create code to make the robots move forward, backward, turn right, and turn left. Following this, a robotics competition was held on a 2 × 1 meter track to test the robots' speed and accuracy in completing their missions. The atmosphere was highly enthusiastic, as teachers were able to directly connect the theoretical knowledge they had gained with practical, real-world applications.

Figure 17. (a) Assembling Robots Using the Gigo S4A Kit; (b) Creating Code to Operate the Robots; (c) Robotics Competition on a 2 × 1 m Track

As a conclusion, a final questionnaire was conducted to evaluate the outcomes of the training. The results showed a significant improvement: 94.7% of teachers reported a better understanding of STEAM concepts, 89.5% felt ready to attempt integrating STEAM into their lesson plans (RPP), and 84.2% stated that they had acquired a basic understanding of coding through the S4A application. These results demonstrate that the training was effective in enhancing teachers' knowledge, skills, and motivation to develop coding- and robotics-based learning.

Mentoring in the Implementation of Coding and Robotic Design Technology

The robotics mentoring was conducted as a follow-up to the previously held training activities. This initiative aimed to ensure that teachers were able to apply the knowledge and skills acquired during the training and integrate them into their classroom lesson plans. During the mentoring sessions, the PKM team worked directly with the Science and Mathematics (MIPA) teachers using a **learning-by-doing** approach. Teachers were encouraged to reassemble simple robots, create command codes using the Scratch for Arduino (S4A) application, and test the functionality of the robots they had built.

During the mentoring sessions, teachers were given the opportunity to practice designing robots, writing command programs, and testing the functionality of their assembled robots. The PKM team provided technical guidance while encouraging teachers to explore creative ideas, such as enhancing the robot's appearance or adding explanatory labels and simple designs to support student understanding. In this way, robotics was framed not merely as a technical tool, but as an engaging and practical learning medium.

The results of the mentoring showed an increase in teachers' confidence in operating the Gigo S4A kit and creating simple coding programs. Teachers were able to independently complete several robotic experiment scenarios, such as moving the robot in four directions, activating indicator lights, and controlling servo motors. Additionally, some teachers began developing ideas to integrate robotic activities into their lesson plans (RPP) as part of project-based learning (Hanik et al., 2021)Through this mentoring, coding and robotic technology are no longer perceived as difficult, but rather as a new opportunity to enhance the quality of learning in a more active, creative, and innovative way.

Figure 17. Teacher Mentoring Activities in Robot Assembly and S4A Application Usage

Conclusion

The implementation of the Community Partnership Program (PKM) at SMA Negeri 1 Ambon through training, mentoring, and the application of coding and robotic design technology has had a positive impact on teachers, students, and the school. Science and Mathematics (MIPA) teachers experienced significant improvements in their understanding and skills in operating the Gigo S4A kit based on Scratch for Arduino (S4A), as well as increased confidence in integrating it into STEAM-based learning (Widiyatmoko, A., Yanitama, A., Arifudin, R., Pamelasari, S. D., Darmawan, M. S., Astutianingtyas, D. F., & Saputra, 2023)Students benefited indirectly through teachers who became better prepared to deliver creative, contextual, and practical learning using coding and robotics. For the school, this initiative served as a foundational step in developing innovative learning approaches aligned with 21st-century demands, while also strengthening the school's image as an educational institution that adapts to technological advancements. Thus, the PKM activities contributed tangibly to creating a more interactive, collaborative, and 21st-century skills-oriented learning ecosystem (Asyhar, 2025).

Acknowledgments

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References

Diocos, C. B. (2023). 21st Century Skills of Practice Teachers: Inputs to Curriculum Enhancement and Instructional Development. *Int J Res Publ Rev*, *4*(1), 300–6.

Kuloğlu, A., and Karabekmez, V. (2022). The Relationship Between 21st-century Teacher Skills and Critical Thinking Skills of Classroom Teacher. *Int J Psychol Educ Stud*, *9*(1), 91–101.

Pramudyani, A. V. R., and Indratno, T. K. (2022). Pemahaman Science, Technology, Engineering, Art dan Mathematic (STEAM) pada Calon Guru PAUD. *J Obs J Pendidik Anak Usia Dini, 6*(5), 4077–88.

Roshayanti, F., Wijayanti, A., Purnamasari, V., Setianingsih, E. S. (2022). Analysis of Understanding and Readiness of Elementary School Teachers on the Implementation of the STEAM (Science, Technology, Engineering, Arts, Mathematics) Approach. In: *4th International Conference on Education and Social Science Research (ICESRE)*, p. 125–34.

Asyhar, R. (2025). *Jurnal Perspektif Pendidikan KRITIS EKSISTENSIALISME TERHADAP BAHAN AJAR ROBOTIK BERBASIS MODEL PjBL DALAM MENINGKATKAN KETERAMPILAN ABAD 21 Jurnal Perspektif Pendidikan*. *19*(2), 280–293.

Balaka, M. Y. (2022). Metode Penelitian Kuantitatif, Kualitatif, Dan R&D. Bandung: CV Alfabeta. *Metodologi Penelitian Pendidikan Kualitatif*, *1*, 130.

Barus, C. S. A., Ringo, S. S., Sitepu, J. E., & Siallagan, Z. L. (2025). STEM Trends in Physics Education Research at The Secondary School Level In Indonesia: A Bibliometric Perspective (2010–2024). *Jurnal Pendidikan Fisika Indonesia*, *21*(2), 179–191. https://doi.org/10.15294/jpfi.v21i2.21496

Hanik, E. U., Ulfa, M., Harfiyani, Z., Septiyani, F., Sabila, N., & Halimah, N. (2021). Pembelajaran berbasis STEM melalui Media Robotika untuk Meningkatkan Keterampilan Siswa Abad 21 Sekolah Indonesia Kuala Lumpur (SIKL). *ICIE: International Conference on Islamic Education*, *1*(1), 83–96.

Hermansyah, H. (2020). Pembelajaran IPA Berbasis STEM Berbantuan ICT dalam Meningkatkan Keterampilan Abad 21. *Jurnal Ilmiah Profesi Pendidikan*, *5*(2), 129–132. https://doi.org/10.29303/jipp.v5i2.117

Widiyatmoko, A., Yanitama, A., Arifudin, R., Pamelasari, S. D., Darmawan, M. S., Astutianingtyas, D. F., & Saputra, A. (2023). Peningkatan pemahaman sains, coding, dan robotik berbasis STEM untuk guru SMP. *Jurnal Abdimas Pendidikan*, *3*(1), 7–14.