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Research Article

Application of pedagogical models in development STEM education in elementary schools

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ABSTRACT

STEM (Science, Technology, Engineering, and Mathematics) education has become the main focus in developing critical, innovative, and problem-based thinking skills in elementary schools. In this context, the application of innovative pedagogical models becomes important to facilitate effective STEM learning. This research aims to dig deeper into the application of pedagogical models in STEM education in elementary schools. Through a qualitative approach, data was collected based on the results of interviews with teachers, direct classroom observations, and document analysis. This data was analyzed using a thematic analysis approach, with steps including transcription, coding, development of analytical categories, and data interpretation. The results showed variations in the application of pedagogical models between the two schools. The results of this research include differences between the two schools, where in School A, the dominant approach is project-based learning, while in School B, collaborative learning is more often used. The challenges faced by each school are also different, with School A facing limited resources such as time and equipment, while School B experiences a lack of support and training for teachers. The teacher's role in implementing the pedagogical model also differs between the two schools. These findings provide valuable insight into the dynamics of STEM learning at the elementary level and have important implications for the development of more innovative and effective learning practices in elementary schools.

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1. INTRODUCTION

STEM (Science, Technology, Engineering, and Mathematics) education has become the main focus in efforts to develop critical, innovative, and problem-based thinking skills from an early age. In the midst of rapid technological developments and global demands for competent human resources in STEM fields, it is important for the education system to prepare future generations through implementing innovative approaches in elementary schools. STEM is an educational approach that was born in the United States and is an abbreviation for Science, Technology, Engineering and Mathematics (Rahmadana & Agnesa, 2022). The STEM approach aims to integrate concepts and skills from the four scientific disciplines into the educational curriculum so that students can learn in an integrated and holistic manner (Zubaidah, 2019), besides that the approach using STEM aims to develop students' skills, such as problem solving

abilities and investigation skills, which is a valuable asset in improving human resources (Hamidah & Ardiansyah, 2023). Through the STEM learning approach, students are encouraged to become active learning agents, where they are guided to find solutions to the problems they face. This allows students to be actively involved in the learning process, by becoming the center of their own learning experience (Riyanto, Fauzi, Syah, & Muslim, 2021). Through this approach, students are expected to develop critical thinking, creativity and collaborative abilities needed to face real-world challenges in the fields of science and technology (Mulyani, 2019).

STEM education at the elementary level is not just about understanding scientific concepts, but also about developing vital practical skills such as problem solving, creativity, and collaboration (Rahmaniah et al., 2023). In an effort to achieve this goal, the application of appropriate pedagogical models is very important in the development of STEM education in elementary schools. A pedagogical model is a systematic framework or approach used by educators to design and implement learning in the classroom. This includes the strategies, techniques and teaching methods selected and applied to achieve certain learning objectives. Pedagogical models help guide the learning process by providing a structure for teachers in preparing learning plans, facilitating interaction between teachers and students, and providing a framework for evaluating learning (Nurdyansyah & Fahyuni, 2016).

By implementing the pedagogical model, teachers adopt an active learning approach, teachers encourage students to be directly involved in exploring scientific concepts through activities such as projects to produce a product, laboratory experiments and problem-based projects. Collaboration is also emphasized, with students encouraged to work together in groups to complete assignments, share ideas, and broaden their understanding. Project-based learning provides a context that is relevant to the real world where students can apply scientific concepts in real situations (Kamaruddin et al., 2023). The integration of Problem-based Learning (PjBL) into the STEM field is very suitable, because STEM is also often related to new projects or discoveries that students can explore and develop (Ananda & Salamah, 2021). Finally, the inquiry approach fosters curiosity and the desire to seek answers on their own by encouraging students to ask questions, investigate phenomena, and find answers through independent exploration (Prasetiyo & Rosy, 2020). Through the use of these pedagogical models, teachers create stimulating and interactive learning environments, helping students gain a deeper understanding of science while developing the relevant skills necessary to succeed in an increasingly evolving world.

According to Fathoni (Fathoni et al., 2020), research exploring innovation in science learning concludes that the STEM learning approach can be considered a breakthrough in developing 21st century skills. By integrating these four disciplines, namely science, technology, engineering and mathematics, the STEM approach provides strong support for developing key 21st century skills known as 4C (Communication, Collaboration, Critical Thinking and Problem Solving, and Creative and Innovative). This research also explains that STEM learning can be easily integrated into various existing learning models, such as cooperative learning models, Problem Based Learning (PBL), Project Based Learning (PjBL), and other learning models.

In this context, this research aims to explore more deeply the application of pedagogical models in the development of STEM education in elementary schools. Through a comprehensive qualitative approach, this research will investigate not only the concrete strategies used, but also qualitative aspects such as teachers' perceptions of the effectiveness of pedagogical models such as the challenges they face in implementation, and their role in facilitating STEM-centered learning. student. By analyzing the data collected in depth, it is hoped that the findings from this research can provide deeper and more nuanced insights into the dynamics of STEM learning at the elementary level. It is hoped that these findings can make a significant contribution to the development of more innovative and effective learning practices in elementary schools, and have the potential to become a basis for improving curricula that are more relevant and responsive to student needs and the demands of the times.

2. METHOD

This research uses a qualitative approach to understand in depth the application of pedagogical models in the development of STEM education in elementary schools. The research subjects consisted of several elementary schools that had implemented a STEM approach in their curriculum. Data collection was carried out through interviews with the teachers involved, direct observation in STEM classes, and analysis of documents such as lesson implementation plans. Qualitative data was analyzed using a thematic analysis approach, with steps including transcription, coding, development of analytical categories, and data interpretation (Al Ghozali & Fatmawati, 2021). The validity and reliability of the research were ensured through data triangulation, reflection, discussion with sources, and consistency of findings with relevant literature and theory (Murdiyanto, 2020). It is hoped that this research can provide an in-depth understanding of the application of pedagogical models in STEM education in elementary schools. In research, it is important to pay attention to ethical aspects. This includes obtaining permission from the school, maintaining data confidentiality, and ensuring that research participants provide informed consent.

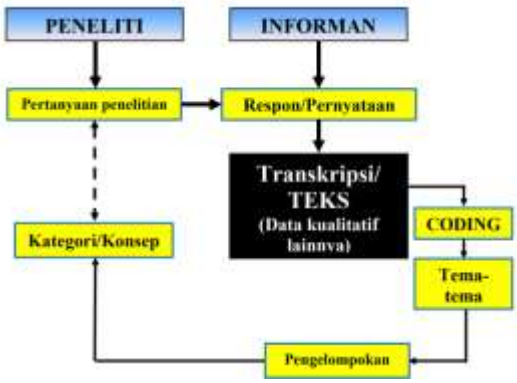

Figure 1. Qualitative data analysis stage (Junaid, 2016)

3. RESULTS AND DISCUSSION

From the data analysis carried out (Figure 1), several important findings can be presented as follows:

a. Strategies for Implementing Pedagogical Models in STEM Learning

Research results from two different schools show variations in the application of pedagogical models for STEM learning at the elementary level. At School A, the most dominant approach is project-based learning, where students are given projects that are challenging and relevant to their daily lives. The teachers at School A actively encourage students to apply STEM concepts in real contexts through these projects. Meanwhile, at School B, the approach that is more often used is collaborative learning. Here, students are invited to work together in small groups to complete STEM tasks. Collaboration between students not only strengthens understanding of concepts, but also develops students' social skills and teamwork skills.

The application of pedagogical models in STEM learning in elementary schools shows variation and adaptation to the needs of local contexts. One commonly encountered strategy is project-based learning. In this approach, students are given projects that are challenging and relevant to their daily lives. These projects are designed to solve concrete problems or overcome challenges that exist in the surrounding environment, giving students the opportunity to apply STEM concepts in contexts that are real and meaningful to them. In addition to project-based learning, collaborative learning approaches are also a focus in STEM teaching. In collaborative learning, students are invited to work together in groups to complete STEM tasks. This collaboration between students not only strengthens understanding of concepts, but also develops their social skills, cooperation skills and communication abilities. Through

collaboration, students learn to appreciate the contributions of each group member and learn from different experiences and perspectives.

By implementing project-based learning and collaborative learning, elementary schools provide learning experiences that are oriented towards problem solving, creativity and active involvement of students. This is in accordance with the goals of STEM education which not only emphasizes mastery of scientific concepts, but also the development of students' critical thinking skills, collaboration abilities and creativity. As a result, students become better prepared to face real-world challenges and gain a deeper understanding of the role of STEM in everyday life.

Through the application of these pedagogical models, educators can create interesting, challenging, and relevant learning experiences for students in STEM learning contexts. The following are concrete strategies for implementing pedagogical models for STEM learning found in this research, namely:

1. Project-Based Learning:

In this research, it was found that a learning model that emphasizes Project Based Learning places students in an active role. Students are given projects that are challenging and relevant to everyday life, which they work on in groups. This allows students to practically apply STEM concepts in real-world situations.

- Identify projects that are relevant and interesting for students, according to the STEM concepts being studied. –
- Form balanced and heterogeneous working groups to increase collaboration and diversity of thought.
- Facilitate the process of planning, implementing and evaluating projects in a structured manner.
- Provide guidance and support to students during the project creation phase to ensure achievement of learning objectives.

2. Problem-based learning (Problem Based Learning)

In this research, it was found that the PBL model places students in situations where they are faced with problems or challenges that require solving. Students actively identify problems, investigate their causes, and seek solutions by applying previously learned STEM concepts.

- Choose problems or challenges that are challenging and relevant to students, which require the application of STEM concepts in solving them.
- Facilitate the process of student investigation and exploration of the problems faced, by providing appropriate guidance.
- Encourage students to identify creative and innovative solutions by applying the STEM concepts they have learned.
- Provide opportunities for students to share and present their solutions, as well as receive feedback from teachers and peers.

3. Collaborative Learning (Collaborative Learning)

In this research, it was found that Collaborative Learning encourages cooperation between students to achieve learning goals. Students learn together in small groups, where they share knowledge, understanding and skills with each other.

- Creating learning activities that encourage collaboration between students in small groups is important in STEM learning. This helps them help each other and better understand scientific and technological concepts.
- Using techniques such as Team Teach, Jigsaw, or Round Robin can get students more active in STEM projects. They can complement each other's STEM knowledge and skills.
- Assigning clear roles to each group member helps students feel true responsibility in completing STEM assignments.
- Joint discussions help students understand STEM concepts better. They can share ideas and get different points of view from their peers.

4. Discovery-based learning (Inquiry-Based Learning)

In this research, it was found that Discovery-Based Learning gives students the opportunity to explore and discover their own knowledge through questions, observations, and experiments. They are given the freedom to organize their own learning, while the teacher acts as a guide. This makes students more active in learning, deepens their understanding of STEM concepts, and develops important research skills.

- Present open-ended questions or challenges that stimulate students' curiosity and encourage them to seek answers through independent exploration.
- Provide resources and access to relevant and varied learning materials, such as books, digital media, and practicum tools.
- Encourage students to plan and conduct small experiments or studies to test their own hypotheses.
- Create space for reflection and discussion about student findings, and relate them to the STEM concepts they have learned.

b. Challenges in Implementing Pedagogical Models in Elementary Schools

The research results also show different challenges in each school. At School A, the main obstacle was limited resources, especially limited time and lack of access to necessary equipment and technology. As a result, teachers at School A often found it difficult to fully implement STEM learning projects. On the other hand, at School B, the main challenge is the lack of support and training for teachers in implementing innovative learning models. Even though they have adequate access to resources, teachers' lack of understanding and skills about STEM concepts becomes an obstacle in delivering the material effectively.

Although efforts have been made to implement innovative pedagogical models in STEM education, teachers and schools face a number of challenges in their implementation. One of the main challenges is related to limited resources, which include limited time, equipment, and teacher knowledge related to STEM concepts. Teachers often feel pressured by limited time to implement the established curriculum, so project-based and collaborative learning can be difficult to implement fully. In addition, not all schools have access to the equipment and technology needed to support practicum and exploration in STEM learning, which can then hinder teachers' ability to provide adequate learning experiences for students. Teachers' lack of knowledge about STEM concepts and lack of training in the use of technology are also barriers to delivering this material. In addition, insufficient support and training for teachers is also an obstacle in implementing effective pedagogical models. Without adequate support, teachers may feel overwhelmed or less motivated to adopt new and innovative learning practices. Therefore, cooperation between various parties, including schools, government, educational institutions, and the industrial community, is essential to overcome these challenges and improve the quality of STEM education at the primary level.

These results are also in line with research conducted by (Nuragnia, Nadiroh, & Usman, 2021). In implementing STEAM learning the same as STEM, several obstacles often arise, including lack of support and understanding of teaching methods, technical challenges, time constraints, access to materials STEAM, and the lack of facilities especially those related to technology. The biggest challenge often expressed by teachers in implementing STEAM is time constraints.

c. The Role of Teachers in Implementing Pedagogical Models

Based on research that has been carried out, the role of teachers in implementing the pedagogical model is very crucial. They act as learning facilitators who not only transfer knowledge to students, but also motivate them to be active in exploration and learning. As leaders in the classroom, teachers have a responsibility to create an environment that supports effective STEM learning. This involves creating an inclusive classroom atmosphere, providing support to all students, and facilitating collaboration between students. In addition, teachers are also responsible for guiding students in completing STEM projects in creative and innovative ways. They not only teach scientific concepts, but also help students develop

problem-solving, critical thinking, and communication skills. Teachers can also identify students' individual interests and talents and provide appropriate support to develop their potential in STEM fields. In this way, teachers are not only transmitters of information, but also mentors, facilitators and inspirers for students on their STEM learning journey. Their active and influential role is key in creating meaningful learning experiences and building a strong foundation for student success in the future.

Discussion

The research results confirmed significant differences between the two elementary schools, namely School A and School B, in the implementation of pedagogical models and the challenges faced in developing STEM education. First, there are differences in the learning strategies implemented in each school. School A is more likely to use a project-based learning approach, while School B prioritizes collaborative learning. These differences indicate variations in approaches to STEM learning at the elementary level, which may be influenced by school culture, curriculum policies, and the needs of students in each setting.

Second, the challenges faced by the two schools are also different. School A experiences limited resources, such as limited time and lack of access to necessary equipment and technology. On the other hand, School B faces challenges in the lack of support and training for teachers in implementing innovative learning models. These differences reflect different barriers to adopting effective STEM learning strategies in elementary schools. The relationship between differences in learning strategies and the challenges faced is that the learning strategies chosen by each school can influence the types of challenges they face. For example, the project-based learning approach used by School A may require more physical resources and time to implement, while the collaborative learning approach used by School B may require more support and training for teachers.

In the context of the discussion, it is important to note that despite differences in learning strategies and challenges faced, both schools have similarities in their efforts to improve STEM education at the elementary level. Both face challenges in overcoming limited resources and support for teachers. Therefore, although the approaches taken may be different, the challenges faced by both schools emphasize the importance of greater support from various parties, including schools, government and related institutions, to improve the quality of STEM education at the primary level.

The discussion also highlights the importance of ongoing professional training and development for teachers so that they can integrate innovative pedagogical models in everyday learning. Quality training will help teachers gain the skills, knowledge, and strategies necessary to teach STEM effectively. Additionally, ongoing training will also help teachers keep up with the latest developments in STEM fields and implement best practices in their teaching. Apart from training, support from the school is also a key factor in the successful implementation of STEM education in elementary schools. Schools need to provide adequate facilities and resources to support STEM learning, including laboratories, equipment and relevant teaching materials. In addition, schools also need to create an environment that supports innovation and experimentation in STEM learning, as well as providing the necessary administrative and supervisory support to ensure successful implementation. By providing adequate training and support to teachers and providing adequate facilities and resources, it is hoped that schools can create a learning environment that allows students to develop optimally in the STEM fields. This will help create a generation that is competent and ready to face the demands of an increasingly complex and changing world.

By paying attention to these findings and discussions, next steps can be directed to three main areas. First, comprehensive training programs for teachers need to be developed so that they can develop the skills, knowledge, and strategies necessary to teach STEM effectively. This program must include an understanding of STEM concepts, the application of innovative pedagogical models, the use of technology in learning, as well as relevant evaluation strategies.

Furthermore, increasing access to supporting resources is crucial. Teachers and schools need to ensure they have adequate access to laboratory equipment, teaching materials, literature and technology. This can be done through adequate budget allocation and collaboration with educational institutions and industry. Lastly, the formation of policies that support the development of STEM education at the primary level must be a priority. This includes the integration of STEM curricula, increased support for teacher training, and the allocation of adequate resources for STEM learning. Through these steps, it is hoped that future generations can be well prepared to face the demands of an increasingly complex and technology-based world.

Based on research conducted by Devi Rakhmawati, the role of teachers in optimizing the pedagogical model is that teachers not only act as transmitters of information, but also as main motivators who inspire students to develop critical thinking, communication, collaboration and creativity skills. Through various learning models such as discovery learning, problem-based learning, project-based learning, and cooperative learning, teachers become facilitators who ensure students learn actively and independently. Teachers also act as effective learning planners by preparing learning plans that are appropriate to learning objectives and student needs. Apart from that, teachers also provide relevant and varied learning resources, as well as carry out evaluations and provide constructive feedback to direct students' progress in developing 4C skills. Thus, the teacher's role is key in creating a learning environment that stimulates the growth of 21st century skills that are important for students' future success (Rakhmawati, Hendrakreatif, Pribadi, & Nurhasanah, 2024).

4. CONCLUSION

The conclusion from the results of this research confirms the importance of implementing pedagogical models in STEM learning in elementary schools. Strategies such as project-based learning and collaborative learning have proven effective in increasing student engagement and understanding of STEM concepts. Through this approach, students are given the opportunity to apply STEM concepts in the context of their daily lives, while collaboration between students strengthens social skills and cooperative abilities. However, there are several challenges that need to be overcome, such as limited resources and teachers' lack of understanding of STEM concepts. To overcome this challenge, greater efforts are needed from various parties, including schools, government and related institutions. Adequate support in the form of training and adequate facilities needs to be provided to teachers to improve their abilities in teaching STEM. Apart from that, it is also necessary to establish policies that support the development of STEM education at the basic level, such as integration of the STEM curriculum and adequate resource allocation. With these steps, it is hoped that future generations can be well prepared to face the demands of an increasingly complex and technology-based world. STEM education at the elementary level will be more effective and have a positive impact on students' academic and professional development.

REFERENCES

Al Ghozali, M. I., & Fatmawati, S. (2021). Pembelajaran daring di sekolah dasar pada era pandemi Covid 19. *EduBase : Journal of Basic Education*, *2*(2), 60. https://doi.org/10.47453/edubase.v2i2.427

Ananda, P. N., & Salamah, U. (2021). Meta Analisis pengaruh integrasi pendekatan STEM dalam pembelajaran ipa terhadap kemampuan berpikir kritis peserta didik. *Jurnal Penelitian Pembelajaran Fisika*, *7*(1), 54–64. https://doi.org/10.24036/jppf.v7i1.111634

Fathoni, A., Muslim, S., Ismayati, E., Rijanto, T., Munoto, & Nurlaela, L. (2020). STEM: Inovasi dalam pembelajaran vokasi. *Jurnal Pendidikan Teknologi Dan Kejuruan*, *17*(1), 33–42.

Hamidah, F. S., & Ardiansyah, A. S. (2023). Telaah bahan ajar berbasis challenge based learning bernuansa STEM terhadap kemampuan pemecahan masalah siswa. *PRISMA, Prosiding*

Seminar Nasional Matematika, *6*, 52–59.

Junaid, I. (2016). Analisis data kualitatif dalam penelitian pariwisata. *Jurnal Kepariwisataan*, *10*(1), 59–74.

Kamaruddin, I., Suarni, E., Rambe, S., Sakti, B. P., Rachman, R. S., & Kurniadi, P. (2023). Penerapan model pembelajaran berbasis proyek dalam pendidikan: Tinjauan literatur. *Jurnal Review Pendidikan Dan Pengajaran*, *6*, 2742–2747.

Mulyani, T. (2019). Pendekatan pembelajaran STEM untuk menghadapi revolusi. *Seminar Nasional Pascasarjana 2019*, *7*(1), 455.

Murdiyanto, E. (2020). Metode penelitian kualitatif (sistematika penelitian kualitatif). In *Yogyakarta Press*. Retrieved from http://www.academia.edu/download/35360663/METODE_PENELITIAN_KUALITAIF.docx

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

Nurdyansyah, & Fahyuni, E. F. (2016). Inovasi model. In *Nizmania Learning Center*.

Prasetiyo, M. B., & Rosy, B. (2020). Model pembelajaran inkuiri sebagai strategi mengembangkan kemampuan berpikir kritis siswa. *Jurnal Pendidikan Administrasi Perkantoran (JPAP)*, *9*(1), 109–120. https://doi.org/10.26740/jpap.v9n1.p109-120

Rahmadana, A., & Agnesa, O. S. (2022). Deskripsi implementasi STEAM (Science, Technology, Enginering, Art, Mathematic) dan integrasi aspek "art" STEAM pada pembelajaran biologi SMA. *JOTE: Journal on Teacher Education*, *4*(1), 190–201.

Rahmaniah, N., Oktaviani, A. M., Arifin, F., Maulana, G., Triani, H., & Jayadi. (2023). *Berfikir kritis dan kreatif: teori dan implementasi praktis dalam pembelajaran* (1st ed.; E. Utomo, F. rakhman Gumelar, & Fahrurrozi, eds.). Jakarta: Publica Indonesia Utama.

Rakhmawati, D., Hendracipta, N., Pribadi, R. A., & Nurhasanah, A. (2024). Peran guru dalam mengoptimalkan model-model pembelajaran berorientasi pada keterampilan Abad 21. *Jurnal Pendidikan Dasar Flobamorata*, *5*(1), 75–85. https://doi.org/10.51494/jpdf.v5i1.1352

Riyanto, Fauzi, R., Syah, I. M., & Muslim, U. B. (2021). Model STEM (Science, Technology, Engineering and Mathematics) dalam pendidikan. In *Journal of Chemical Information and Modeling* (Vol. 53).

Zubaidah, S. (2019). STEAM (science, technology, engineering, arts, and mathematics): Pembelajaran untuk memberdayakan keterampilan abad ke-21 [STEAM (Science, Technology, Engineering, Arts, and Mathematics): Learning to Empower 21st Century Skills]. *Seminar Nasional Matematika Dan Sains*, (September), 1–18.