SYAIKHUNA: Jurnal Pendidikan dan Pranata Islam STAI Syichona Moh. Cholil Bangkalan
p-ISSN:2086-9088, e-ISSN: 2623-0054
DOI: https://doi.org/10.62730/syaikhuna.v15i2.7477

Enhancing Science Education through the STEM Model

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Abstract: *The purpose of the study was to explore the implementation of the STEM (Science, Technology, Engineering, and Mathematics) learning model and its impact on students' critical thinking skills and Creativity. The methodology used is qualitative, with data collection techniques through in-depth interviews, classroom observations, and document analysis. Participants consisted of teachers and students in several Madrasah Ibtidaiyah implementing the STEM model. The main results showed that implementing the STEM model significantly improved students' critical thinking skills, with many students reporting improvements in their ability to solve problems and collaborate on group projects. In addition, teachers reported that this approach made learning more interesting and relevant to students. The implications of this study confirm that integrating the STEM model in the Madrasah Ibtidaiyah curriculum not only strengthens conceptual understanding but also equips students with the skills needed to face future challenges.*

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Keywords: *STEM, Science Education, Elementary Madrasah, Critical Thinking Skills*

Abstrak: *Tujuan penelitian adalah untuk mengeksplorasi penerapan model pembelajaran STEM (Science, Technology, Engineering, and Mathematics) dan dampaknya terhadap keterampilan berpikir kritis serta kreativitas siswa. Metodologi yang digunakan adalah pendekatan kualitatif, dengan teknik pengumpulan data melalui wawancara mendalam, observasi kelas, dan analisis dokumen. Partisipan terdiri dari guru dan siswa di beberapa Madrasah Ibtidaiyah yang telah menerapkan model STEM. Hasil utama menunjukkan bahwa penerapan model STEM secara signifikan meningkatkan keterampilan berpikir kritis siswa, dengan banyak siswa melaporkan peningkatan dalam kemampuan mereka untuk memecahkan masalah dan berkolaborasi dalam proyek kelompok. Selain itu, guru melaporkan bahwa pendekatan ini membuat pembelajaran lebih menarik dan relevan bagi siswa. Implikasi dari penelitian ini menegaskan bahwa integrasi model STEM dalam kurikulum Madrasah Ibtidaiyah tidak hanya memperkuat pemahaman konseptual tetapi juga membekali siswa dengan keterampilan yang diperlukan untuk menghadapi tantangan masa depan.*

Kata Kunci*: STEM, Pendidikan Sains, Madrasah Ibtidaiyah, Keterampilan Berpikir Kritis.*

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Submitted: 06-08-2024 Accepted: 20-08-2024 Approved: 23-09-2024 Published: 30-10-2024

p-ISSN:2086-9088, e-ISSN: 2623-0054
DOI: https://doi.org/10.62730/syaikhuna.v15i2.7477

Introduction

Modern science education faces new challenges in providing students with an in-depth understanding of scientific concepts and critical thinking skills necessary in the face of rapid changes in today's world. This change in science education demands innovative and effective approaches to improve students' understanding of science. One approach that has received attention is the STEM *(Science, Technology, Engineering, and Mathematics)* approach, which combines concepts from various disciplines. Madrasah Ibtidaiyah Darussalam Kedunggalar is important in building students' understanding of scientific concepts. However, traditional teaching methods often do not increase student interest and participation. Therefore, the learning model requires innovations that stimulate students to think critically, work in teams, and apply knowledge in real-life situations.

The combination of STEM approaches in science education at Madrasah Ibtidaiyah Darussalam Kedunggalar has great potential to increase student interaction with science concepts and provide more contextual learning. Previously, there have been several studies related to STEM integration efforts to improve the understanding of science sciences. Research by Elisabeth Irma Novianti Davidi (2021) shows that STEM integration can improve students' critical thinking skills. Through real-world problem-solving projects, students develop the ability to analyze, investigate, and formulate solutions to scientific challenges. STEM integration also encourages collaboration between disciplines, allowing students to see the relationship between science, technology, engineering, and mathematics in a broader context. The PBL model has been proven to be a learning method that can increase student motivation. When students engage in projects that are relevant to real life, they tend to be more motivated and excited about learning (Nurul Fadhilah et al., 2022).

In this context, this study aims to determine the effectiveness of implementing the STEM approach in science learning (IPA) at Madrasah Ibtidaiyah Darussalam Kedunggalar. By analyzing the impact of this approach on student engagement, conceptual understanding, and problem-solving skills, this study plans to make a real contribution to developing more relevant and effective science education at the madrasah level. This research will quantitatively measure the increase in students' understanding of science concepts that follow the STEM integration approach. This article focuses on merging two innovative learning approaches, namely STEM

p-ISSN:2086-9088, e-ISSN: 2623-0054
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integration, to improve understanding of science. This research will provide in-depth insights into how this approach can provide better results than conventional methods. Despite previous research on STEM integration, research gaps still need to be addressed. STEM approaches in madrassas have yet to be explored enough in the local context. Previous research generally focused on the context of general education or high school without considering the uniqueness of the madrasah ibtidaiyah. Therefore, this study aims to fill this gap by exploring the application of STEM approaches through Madrasah Ibtidaiyah Darussalam Kedunggalar. In the international literature related to the application of STEM in primary education or madrasas, several studies show that STEM integration not only improves students' conceptual understanding but also students' critical and collaborative thinking skills (Mullini, 2019)(Capraro et al.; M.M., 2013) (Ejiwale et al. (2013). Barriers to successful implementation of STEM education. Journal of Education and Learning, Vol.7(2), 2013).

Research by Moore, T. J. (2016). shows that integrated STEM education effectively builds connections across curriculum areas that are considered important by education professionals. In addition, research by Yuliati et al. (2019) emphasizes that applying STEM approaches can make students better at solving problems and independent and technologically literate. This shows that the application with STEM approaches can help students not only understand scientific concepts but also apply them in real-life situations. Thus, this research is expected to provide valuable guidance for the development of curriculum and learning practices in the field of science education at Madrasah Ibtidaiyah Darussalam Kedunggalar and contribute to the development of more relevant and effective science education at the madrasah ibtidaiyah level in general.

Modern science education faces a great challenge to equip students with deep understanding and critical thinking skills to face the rapidly changing world. The STEM *(Science, Technology, Engineering, Mathematics*) approach has emerged as one of the innovative solutions that can increase students' absorption of science by bringing together various disciplines to create a holistic learning experience. At Madrasah Ibtidaiyah Darussalam Kedunggalar, this approach can help overcome the limitations of traditional teaching methods that often do not attract enough interest and student participation. With more interactive and problem-solving-oriented approaches, such as STEM integration, students can be encouraged to think critically, work together in

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teams, and apply knowledge in real-world contexts.

However, gaps in implementing this STEM approach, especially in madrasah environments, still need further exploration related to STEM adaptation by local values. Previous research has shown that STEM integration can improve students' critical thinking skills by involving them in projects relevant to daily life. In addition, this approach also allows students to understand the interconnectedness between science, technology, engineering, and mathematics more broadly, enhancing their interdisciplinary understanding. Research conducted by Elisabeth Irma Novianti Davidi (2021) revealed that the STEM approach combined with PBL is able to encourage students' analytical skills and learning motivation higher than conventional methods.

Modern science education faces new challenges in providing students with an in-depth understanding of scientific concepts and critical thinking skills necessary for rapid change. This change in science education requires an innovative and effective approach to increase students' absorption of science. The approach that has received attention is the STEM *(Science, Technology, Engineering, and Mathematics)* approach, which combines concepts from various disciplines. Madrasah Ibtidaiyah Darussalam Kedunggalar is important in students' understanding of scientific concepts. However, traditional teaching methods often do not increase student interest and participation. This learning model puts students in an active role in solving real problems where they face challenges that require in-depth analysis, research, and problem-solving.

Previously, several studies related to the integration of STEM *(Science, Technology, Engineering, and Mathematics)* to improve the understanding of science science. Some of the key findings from previous studies are: STEM Integration Improves Critical Thinking Skills, Previous research has shown that the STEM Integration approach can significantly improve students' critical thinking skills. Through projects involving real problem-solving, students develop the ability to analyze, investigate, and formulate solutions to scientific challenges (Elisabeth et al., 2021).

STEM integration encourages collaboration between different disciplines, STEM integration encourages collaboration between different disciplines. It allows students to see the broader context of the relationship between science, technology, engineering, and mathematics. This contributes to a deeper understanding of how these sciences are interrelated ((Elisabeth et al., 2021), and the PBL model has been proven to be a

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learning method that can increase student motivation. This is proven to be a learning method that can increase student motivation. When students are involved in projects that are relevant to real life, they tend to be more motivated and enthusiastic about learning (Nurul Fadhilah*, Nurdiyanti, Anisa, Muhammad Wajdi, 2022).

This article focuses on combining two innovative learning approaches, STEM Integration and PBL model, to improve science understanding. This research will provide in-depth insights into how this approach can produce better results than conventional methods. By exploring the relationship between STEM Integration, PBL Model, and understanding of science, this research has the potential to provide valuable guidance for curriculum development and learning practices in the field of education.

Research Methods

Research methods are scientific ways to obtain information for specific purposes. A research method is also a theoretical analysis of a method or method. Research is systematic research to increase knowledge and a systematic and organized effort to investigate problems that require specific answers (Sugiono. (2017). Educational Research Methods: Quantitative Approach, Qualitative, 2017). This article uses qualitative research with case studies *(case study)*, a form of qualitative research based on understanding human opinion and behavior (Polit et al., 2004). The object of research is individuals, groups, institutions, or communities. The subject of the study was a grade IV student of MI Darussalam Kedunggalar. The research used includes classroom observation, teacher interviews, and documentation. The information obtained was analyzed thematically to determine the effect of introducing the STEM approach on student participation in science learning (IPA). The data collection process involves classroom observations, interviews with teachers, and documentation, which are processed thematically to understand the impact of these two methods on science learning. Qualitative data collection techniques are used to collect descriptive, in-depth, and unstructured data.

This technique aims to understand and explain complex phenomena, such as individuals' or groups' attitudes, perceptions, and experiences. Data collection techniques include primary and secondary sources, which aim to obtain descriptive and in-depth information. The data collected is then systematically analyzed, including

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data classification based on theme or category, to provide a clear and thorough interpretation of the studied phenomenon. According to Sugiyono, data collection can be carried out in various ways: *Settings*, sources, and various other ways. Data collection can use primary and secondary data sources when viewed from the data source. Primary sources are data sources that directly provide data to data collectors. In contrast, Secondary data sources do not directly provide data to data collectors, for example, through other people or documents. Furthermore, data collection methods or techniques can be viewed through observation, interview, and documentation. Next is analyzing data, which is compiling data to be interpreted. Data preparation follows data classification with specific patterns, themes, or categories. The first step in data analysis is data collection, improving the data framework so that it is more accurate, collecting weak data elements empirically so that it is more meaningful, reinterpreting data through relationships between data, through changes that lead to data collection to facilitate the implementation of the next research(Saebani, 2008). In qualitative research, data is obtained from various sources using various data collection techniques and carried out continuously until the data is valid. With such continuous observation, data variation is very high, so it is often difficult to conduct analysis. Nasution stated that analysis is a very difficult job that requires hard work. Analysis requires Creativity and very high intellectual ability. There is no specific way to conduct an analysis, so each researcher must find the method that he or she feels is suitable for the nature of the researcher. Different researchers could clarify the same material. Can produce memorable student learning experiences by systematically combining knowledge, concepts, and skills. With a STEM approach, learning is expected to improve skills or abilities in the era of globalization, and students are expected to be able to function in society and apply and develop concepts related to solving complex problems in daily life in the field of science. There are four disciplines in the STEM access process: 1) Science is learning that integrates the natural sciences. 2) Technology is a combination of technology and science, usually associated with today's modern technology that has developed rapidly by humans. 3) design works or designs with the right methods that can solve problems and are useful for human life. 4) Mathematics can drive technological innovation and produce the right scientific language in science (IPA), technology, and engineering (Nida'al Khairya, 2019).

Results and Discussion

p-ISSN:2086-9088, e-ISSN: 2623-0054
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Based on the results, it can be stated that data analysis is the process of systematically searching for and compiling data obtained from the results of interviews, report notes, and documentation by organizing data into categories, describing into units, synthesizing, organizing into patterns, choosing which ones are important to be studied, and making conclusions so that they are easy to understand by yourself and others. In qualitative research, the data collected is not numbers but in the form of words or pictures. The data can come from interview scripts, field notes, photos, videos, and recorders. In qualitative research, data analysis is more focused during the field process along with data collection:

a. Analysis before the field

Data from the preliminary study or secondary data are analyzed to determine the focus of the research. However, the focus is still temporary and will develop after the researcher enters the field.

b. Data analysis in the field

After the data was collected within a certain period, at the time of the interview, the researcher analyzed the answers that were interviewed after being analyzed felt unsatisfactory. Hence, the researcher continued the question until a certain stage and obtained data that is considered credible; Miles and Huberman stated that activities in qualitative data analysis are carried out interactively and take place continuously until complete so that the data is clear. The analysis is carried out interactively and continuously, both before and during the data collection process in the field, ensuring the credibility of the data obtained until the research reaches relevant and meaningful conclusions for science learning at MI Darussalam.

The Implications of Implementation of the STEM Approach through the PBL Model in science learning at Madrasah Ibtidaiyah Darussalam Kedunggalar has several important implications:

1. Increased Student Engagement: The application of this approach encourages students to be more actively involved in the learning process. By facing real problems, students become more motivated to find solutions, which increases their curiosity about scientific concepts (Darmawan & Setiawan, 2022).
2. Problem-Solving Skills Development: The STEM-integrated PBL model allows students to develop better problem-solving skills. They learn to identify

Submitted: 06-08-2024 Accepted: 20-08-2024 Approved: 23-09-2024 Published: 30-10-2024

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problems, analyze information, and formulate creative solutions (Agung Purwanto et al., 2021).

3. Collaborative Skills: Problem-based learning encourages cooperation between students, which is important in real-world contexts where collaboration is often required to solve complex problems.

4. Creativity and Innovation: This approach also stimulates students' Creativity by providing them with opportunities to create innovative solutions to the problems they face (Agung Purwanto et al., 2021).

5. Deep Understanding of Concepts: By implementing active learning, students memorize facts and understand concepts in depth through experiments and practical projects.

In the context of previous research, there are some significant similarities and differences; previous research similarities have also shown that integrating STEM into problem-based learning can improve student motivation and engagement (Johnson & Smith, 2019). This aligns with the findings at Madrasah Ibtidaiyah Darussalam Kedunggalar, where students showed increased participation and curiosity. While previous research may have focused more on the theoretical aspects of STEM implementation, research at MI Darussalam Kedunggalar highlights practical implementation and its challenges. For example, this study may have yet to be discussed in depth in previous studies because time-related constraints and the availability of tools and materials are major focus areas. Previous research has shown improved student learning outcomes through the STEM approach (Agung Purwanto et al., 2021). However, research at MI Darussalam Kedunggalar provides concrete evidence of how this approach can be applied in a local context and its impact on understanding science concepts. Thus, the application of STEM approaches is relevant and effective in improving the quality of science education at the primary level, contributing positively to the development of essential skills for students. How the application of the STEM approach affects student learning motivation Based on research data obtained through observation, interviews, and documentation of the science learning process (IPA) at MI Darussalam Kedunggalar in designing a STEM approach using a problem-based learning model of 30 students. Class IV Results of MI

p-ISSN:2086-9088, e-ISSN: 2623-0054
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Darussalam Kedunggalari Class IV Science Results at MI Darussalam Kedunggalar, the researcher found that the design process described in the data description was using STEM.

The approach that needs to be considered is to create a learning concept that starts from the lesson plan and related learning tools. The STEM approach in science learning (IPA) is implemented with animal life cycle materials, and the use of living objects at MI Darussalam Kedunggalar is also considered effective because it facilitates student learning. Learning concept. Teachers use the STEM approach of animal life cycles and the utilization of living things to provide opportunities for students to participate in learning actively. In the learning process, teachers act as facilitators and motivators, meaning that if students have difficulty understanding material concepts, teachers can open students' understanding through the explanations provided.

Implementation Implementation of the STEM approach in grade IV Science. In implementing learning, teachers play a role in creating active and effective learning. Learning can be active if teachers provide opportunities for students to actively acquire their knowledge about the teacher's learning outcomes. Students get this information from activities carried out by students rather than activities carried out for students. Effective learning facilitates students learning of useful information, such as facts, skills, values, and concepts, which naturally results from student activities through active learning. To implement such learning, learning using a problem-based learning model that uses a STEM approach can provide opportunities for students to use all their thinking skills to solve a problem. In this learning, students are encouraged to identify problems, find new ideas to solve problems, analyze new ideas found so that they can be applied, apply new ideas, and conclude the problems solved. In implementing STEM approach learning, analysis of learning steps and procedures, including 1) Learning preparation includes preparation before learning by examining models, approaches, and teaching. Materials used in education. Several things must be prepared, namely LKS, science package books, and discussion questions, which students will use and work on later. 2) Opening Information and introduction to the initial study are carried out by greeting, praying, asking for news, and checking the list of students attending the meeting. The teacher will then give an initial explanation of what will be taught. After the teacher explained the pre-technical learning, the teacher

p-ISSN:2086-9088, e-ISSN: 2623-0054
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communicated the learning results achieved in the meeting. The teacher passed yesterday's lesson and then asked questions related to the specified material, namely. The life cycle of animals and the use of living things. As well as the formation of study groups. The purpose of this study group is to facilitate student learning. 3) Basic Function: The basic function starts with providing materials related to animal life cycle materials and using living things. The material debriefing includes teaching materials and instructions for making an object related to the life cycle of animals and the use of living things. The teacher directs students to observe living things around them related to their knowledge. Of course, the delivery of this material uses a STEM approach using a problem-based learning model.

STEM approach stands for *Science, Technology, Engineering, and Mathematics*. STEM has been described as a way of learning that combines technological concepts with science or math learning. The STEM approach is different and can meet the learning objectives in the classroom. The explanation of natural science, namely. The teacher explained the material about the life cycle of animals and the use of living things and technology. The teacher explains how to make a simple problem-solving pencil case from animal life cycle materials and how to use it. Living creatures; technique learning, where teachers and students make simple pencil cases and explain the operation and working of simple pencil cases; Mathematics, where the teacher invites students to measure the length and width of the pencil case they make. Applying the problem-based learning model to the STEM approach in scientific learning begins with a problem that will be solved with the material taught to students. The assignment can come from the student or directly from the teacher, after which the student learns to focus on learning the problem about the problem; in other words, they learn scientific theories and methods to solve the problem that is the focus of their attention. The STEM approach applied to the first stage of learning uses a STEM approach in Learning: Following the teacher in the observation process motivates problems related to scientific concepts taught in daily life. Problems were found in this survey; for example, some stationery and books were scattered; the second was New Ideas. From the observations, students sought more information and defined new ideas from analysis and critical thinking results. Teachers, as supervisors, guide and assist students in learning; the third is innovation. After explaining the analysis results

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and the ideas obtained, students discuss these ideas, which will later be applied in problem-solving; the fourth is Creativity. That is, this Creativity is more about the results of discussions on the formulation of ideas and the generation of innovation. Simple Making Pencils from Ice Cream Sticks: In the guide to making Seura or simple pencil boxes using ice cream sticks, the teacher explains the benefits of making pencils in daily life.

Factors inhibiting the STEM *(Science, Technology, Engineering and Mathematics)* approach in science subjects at Madrasah Ibtidaiyah

Obstacles to the Implementation of the Problem-Based Learning Model with a STEM Approach to Improve Problem-Solving Skills in Class IV MI Darussalam Kedunggalar STEM Approach Obstacles to the Implementation of PBL Madrasah Ibtidaiyahmal Material Cycle Science Model and Classroom Layout Class IV MI Darussalam Kedunggalar Using Objects, namely as follows: 1) The application of a problem-based learning model with a STEM approach to improve students' problem-solving skills It takes a long time because in the learning process must go through several stages, for example, students understand the problems presented, then students understand that students learn from the problems presented. Students look for new ideas to solve the problem; then, they analyze the ideas they find so that they can solve the problem. When students apply the ideas they find, they conclude the problem they solve. Learning by applying a problem-based learning model with a STEM approach in Class IV IPA MI Darussalam Kedunggalar takes 2 hours or 2 x 45 minutes. 2) Applying a problem-based learning model with a STEM approach to improve animal life cycle materials, problem-solving skills, and the benefits of living things. Class IV MI Darussalam Kedunggalar requires tools and materials that schools usually do not have, so teachers must prepare themselves. Tools and materials because they want to help students. However, this can be overcome by using tools and materials obtained from goods used in various parts of the school.

Improvement of Learning Outcomes.

Several studies show that STEM integration can improve student learning outcomes, especially in understanding science concepts. In addition, it has also been proven to be a learning method that can increase student motivation. These studies show that STEM Integration can improve students' critical thinking skills, allow

Submitted: 06-08-2024 Accepted: 20-08-2024 Approved: 23-09-2024 Published: 30-10-2024

p-ISSN:2086-9088, e-ISSN: 2623-0054
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students to see the relationship between science, technology, engineering, and mathematics in a broader context, and encourage collaboration between different disciplines. Integrating the four aspects of STEM in learning can also help students solve contextual and conceptual problems more comprehensively and meaningfully (Agung Purwanto et al., 2021). In the context of research that wants to investigate the effectiveness of STEM Integration in the PBL Model in improving students' understanding of science, previous research has shown that this approach can provide better results than conventional methods. Therefore, integrating STEM in the PBL model can be one of the efforts to improve student learning outcomes in science. The results of interviews with the HWP brothers regarding STEM learning evidence this

"STEM is not just a lesson, but more like playing a game. We can see how that knowledge can be used to make cool things. So learning becomes more interesting!" Then, it was proven by an interview with the principal, "STEM integration helps children develop the skills needed to succeed in the field of science and technology." it helps children develop the skills needed to succeed in the field of science and technology because it is Interdisciplinary. The STEM approach integrates various disciplines, such as science, technology, mathematics, and engineering. This helps children understand how these different aspects of science are interconnected, reflecting the complexity of the real world. The second is problem-based learning; It teaches them analytical, problem-solving, and critical thinking skills essential in science and technology. In addition, students must have Creativity. Moreover, Creativity: The integration of STEM in problem-based learning encourages Creativity and innovation. Children are invited to create innovative solutions to their problems, similar to the approaches used in science and technology.

STEM abilities also develop important abilities in scientific and technological work that often involve work teams. Thus, the integration of STEM in the PBL Model creates a learning environment that supports the development of essential skills for success in the fields of science and technology, while promoting a deeper and contextual understanding of the subject matter.

"Learning science using STEM is like playing while learning. We can experiment, like making water rockets or hydroponic plants. So, we do not just read it."

With STEM, students can conduct experiments and projects such as building

p-ISSN:2086-9088, e-ISSN: 2623-0054
DOI: https://doi.org/10.62730/syaikhuna.v15i2.7477

water rockets or growing hydroponic plants. This allows them to experience and apply science concepts firsthand, which is much more profound than reading texts. Students can develop a deeper understanding of science, technology, engineering, and mathematics through experiments and projects. They also learn to think critically, solve problems, and collaborate with classmates, skills crucial in the real world. So, learning science with a STEM approach means more than just reading a book or memorizing facts. More so, it is a learning experience involving hands, mind, and Creativity, making science learning more engaging and meaningful.

Conclusion

Based on the research and discussion results, this study illustrates the importance of the STEM approach in the context of science learning at Madrasah Ibtidaiyah. Several important conclusions can be drawn from the results of the research and analysis: The application of STEM approaches increases student engagement. Applying the STEM approach results in more active and challenging learning for students. The problem-based challenges presented encourage students to think critically, collaborate, and actively participate in the learning process. Understanding science concepts increases the number of students who learn using the PBL model and have a deeper understanding of science concepts. The analysis process, inquiry, helps students relate abstract concepts to real-world situations. STEM approaches in science learning at Madrasah Ibtidaiyah create innovative approaches that combine elements of science, technology, engineering, mathematics, and problem-solving in a single context. This provides opportunities for students to develop a more holistic understanding of the sciences, encourage problem-solving skills, and stimulate critical thinking. The results of this study provide strong support for applying STEM approaches in science learning. Students who follow this approach have consistently improved critical thinking skills and understanding of science concepts. Therefore, STEM approaches are not only effective methods, but they are also relevant in preparing students for future science challenges. This approach is careful, and continuous application is expected to provide long-term benefits for science education. The application of the STEM approach is an effective strategy for improving the quality of science learning. This study will greatly contribute to efforts to develop more dynamic and relevant educational science in the educational environment of Madrasah Ibtidaiyah Darussalam Kedunggalar.

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p-ISSN:2086-9088, e-ISSN: 2623-0054
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