Pesantren 4.0: Integration of Steam in Classical Learning for Today's Students

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Abstract

The Industrial Revolution 4.0 has brought great changes in the world of education, including in the Islamic boarding school environment which has been relying on classical learning methods based on the yellow book. The gap in the use of information and communication technology (ICT) has caused pesantren to face challenges in preparing students to be able to compete in the digital era. The STEAM (*Science, Technology, Engineering, Art, and Mathematics*) approach is a solution that can be applied to improve the quality of learning in Islamic boarding schools without eliminating traditional values. This study uses a descriptive qualitative method with a case study approach at the Tri Bhakti Attaqwa Rama Puja Raman North Islamic Boarding School, East Lampung to explore the application of STEAM in the classical system. Data collection techniques were carried out through direct observation, in-depth interviews, and documentation studies, which were then analyzed by thematic analysis methods. The results show that the integration of STEAM in Islamic boarding school learning can improve 21st century skills, including critical thinking, creativity, and problem-solving. However, there are challenges in its implementation, such as the limitations of digital infrastructure, low technological literacy among students and teaching staff, and the need for special training for teachers in implementing STEAM. Therefore, an adaptation strategy is needed that maintains classical methods but still accommodates the use of technology in learning. This study provides recommendations for Islamic boarding schools to develop learning models that are more innovative and adaptive to the times.

Keywords: STEAM, pesantren education, Industrial Revolution 4.0, classical learning, 21st century skills.

Introduction

The Industrial Revolution 4.0 era has changed the order of human life, including in the education sector, where information and communication technology (ICT) is the dominant element in transforming learning methods (Dash et al., 2019; Ghani & Muhammad, 2019; Muktiarni et al., 2019). The shift from teacher-centered learning to student-centered learning has enabled students to be more active and independent in accessing learning resources digitally (Anning, 2025; Tambak et al., 2023; Wafula & Ongunya, 2016). With the presence of artificial intelligence (AI), Internet of Things (IoT), and big data, the world of education has experienced a revolution in terms of teaching and evaluation (Aldowah et al., 2017; Dash et al.,

2019; Han et al., 2020; Lee, 2019). However, on the other hand, educational institutions that still rely on traditional learning methods face great challenges in adapting to these changes (Briggs et al., 2019; Rachmad, 2019; Timotheou et al., 2023). This technological inequality also has an impact on Islamic boarding schools, known as the classical book-based learning model, where the limitations of the use of technology are often an obstacle for students in facing an increasingly competitive world (Halimah et al., 2024; Intania & Nurcholis, 2024).

Islamic boarding schools as Islamic educational institutions have a sorogan, bandongan, and wetonan learning system, which focuses on studying texts and deepening religious knowledge through memorization methods and

discussions with kiai (Halimah et al., 2024; Jamil, 2024; Ma'Arif, 2018). However, this approach has not fully prepared students to face challenges in the digital era, especially in terms of technological literacy, critical thinking skills, and innovation that are the main demands in the modern world. The lack of access to technology facilities, the lack of digital competence of educators, and the limitations of digital infrastructure in Islamic boarding schools have further widened the education gap between Islamic boarding schools and other formal education systems (Maria Ulfa, pre-research interview, September 15, 2024). Therefore, a new breakthrough is needed that can bridge the traditional learning system of Islamic boarding schools with technological advances without eliminating Islamic identity and values.

The STEAM (*Science, Technology, Engineering, Art, and Mathematics*) approach is an innovative solution that can be implemented in the pesantren education system to develop 21st century skills, such as critical thinking, problem-solving, creativity, and collaboration (Chalkiadaki, 2018; Widiastuti et al., 2024). By integrating STEAM in teaching methods in Islamic boarding schools, students not only understand religious texts in depth, but can also relate them to modern scientific and technological phenomena. According to Mufidah (2019), the application of STEAM is able to create a more dynamic, project-based, and contextual learning environment, so that students are better prepared to face a technology-based world without losing the essence of Islamic education. Therefore, this study aims to examine how the integration of STEAM in the classical pesantren system can improve the quality of education, provide solutions to technological limitations in the pesantren environment, and develop a learning model that can accommodate the development of the times without eliminating the intellectual heritage of Islam. With this approach, it is hoped that the pesantren education system will be able to produce graduates who not only excel in religious understanding, but also have technological competence and innovation that are ready to compete at the global level.

Research Objectives
The objectives of this study are:

1. Analyzing the Digital Divide in Islamic Boarding School Education;
2. Exploring Educators' and Students' Understanding of STEAM;
3. Developing a STEAM Integration Model in Classical Learning in Islamic Boarding Schools;
4. Evaluating the Effectiveness of the Implementation of STEAM in Islamic Boarding Schools;
5. Offering a Contextual STEAM Implementation Strategy for Islamic Boarding Schools.

Research Benefits
This research is expected to provide the following benefits:

Theoretical Benefits

1. Contributing to the development of the theory of STEAM integration in the Islamic boarding school learning system, especially in the context of Islamic education in the era of the Industrial Revolution 4.0.

2. Enriching scientific studies on the application of STEAM in a classical book-based educational environment.

Practical Benefits

1. For Islamic Boarding Schools

- Providing an innovative learning model that maintains traditional methods but is more adaptive to technological developments.
- Assisting Islamic boarding schools in overcoming digital literacy challenges and technological infrastructure in learning.

2. For Students

- Improve 21st century skills, such as critical thinking, creativity, problem-solving, and collaboration.
- Provide a more contextual and applicative learning experience by utilizing technology.

3. **For Educators**

   o Provide new insights into STEAM-based teaching methods that can be adapted in learning the yellow book.
   o Improving teachers' competence in utilizing technology as a teaching tool without eliminating the essence of the classical method of pesantren.

4. **For Other** Researchers

   o It is a reference for advanced research that focuses on the transformation of pesantren education in the digital era.
   o It is the basis for the development of STEAM-based education policies in the environment of Islamic boarding schools and other Islamic educational institutions.

Research Methods

This study uses a descriptive qualitative approach with a case study method at the Tri Bhakti Attaqwa Rama Puja Raman North Islamic Boarding School, East Lampung. The case study was chosen because it allows an in-depth exploration of the application of STEAM in the classical learning system in Islamic boarding schools. With this approach, the research seeks to understand the dynamics of STEAM-based teaching, identify the obstacles faced by Islamic boarding schools in its implementation, and evaluate the effectiveness of these methods on the development of students in cognitive, affective, and psychomotor aspects. The main focus of the research is how STEAM can be adapted without eliminating the fundamental values of pesantren as a center for yellow book-based education. In addition, this study also considers how the integration of technology in learning can increase students' interest in learning without eliminating the essence of traditional methods that have become the heritage of Islamic boarding schools.

Data collection techniques involve direct observation, in-depth interviews, and documentation studies. Observations were carried out to observe the interaction between students and ustaz in the learning process and how technology is applied in teaching and learning activities. In-depth interviews were conducted with students, educators, and pesantren managers to explore their understanding of the effectiveness of the STEAM approach. Documentation studies were used to analyze teaching materials, pesantren curriculum, and educational policies that affect the application of this method. In addition, data analysis was carried out longitudinally to see long-term changes in the implementation of STEAM in Islamic boarding schools. The data obtained was analyzed using a thematic analysis method, through the stages of data reduction, categorization, data presentation, and conclusion drawing to obtain a comprehensive picture of the integration of STEAM in pesantren education. The validity of the data is strengthened by the triangulation technique of sources and methods, namely comparing the results of observations, interviews, and documentation so that the research results are more accurate and can be accounted for academically. In addition to triangulation of methods, data verification is also carried out through discussions with Islamic education experts and STEAM experts to ensure the relevance of research findings to the needs of Islamic boarding schools in the modern era.

Results and Discussion

Based on the results of observations and interviews with ustadz/teachers who teach in classes at the Tribakti Attaqwa Islamic Boarding School, it is known that the ustadz/teacher who teaches in the 2nd grade of the Al-Qur'an Upper High School (SMAQ) has not used the STEAM (*Science, Technology, Engineering, Art and Mathematic*) approach learning in the teaching process at the Tribakti Attaqwa Islamic Boarding School, even some ustadz/teachers still do not understand what STEAM is. In fact, the teachers/ustadz said that the teaching and learning process at the Tribakti Attaqwa Islamic boarding school applies classical learning.

Classical learning at the Tribakti Attaqwa Islamic boarding school begins with a small book (mabsuthât) containing concise and simple texts, then moves to the medium book level (mutawassith). The lessons are given in the form of an open lecture, where the kiai reads, translates, and explains the books studied. Likewise, in the learning process when students are formal schools (SMPQ, MTs, SMAQ, SMK, SMA, and MA) The empirical reality actually describes the condition of traditional Islamic

boarding schools, which in other terms are called salafi, in Indonesia.

Based on the observations and interviews above, there is a need for a new strategy in the learning process in Islamic boarding schools, especially in formal schools in the current digital era, educational technology as a supporting material in the learning process by applying the STEAM (*Science, Technology, Engineering, Art and Mathematic*) learning approach) without ignoring the classical learning that has been applied in the Attaqwa Rama Puja tribakti Islamic boarding school, North Raman district, East Lampung Regency, Lampung Province. The results of the study show a description of the effectiveness of the STEAM (since, technology, engineering, art and mathematics) learning approach to classical learning at the Tri Bhakti Attaqwa Rama Puja Raman North Islamic boarding school, East Lampung.

1. Implementation of Learning at the Tribakti Attaqwa Islamic Boarding School.

Based on the results of the author's observations, interviews, and documentation above, the data description is an effort so that the collected data can be presented clearly, in detail, and easily understood by the reader. The results of the research obtained regarding the implementation of STEAM-based learning in the students of the Tribakti Attaqwa Rama Puja Raman North Islamic Boarding School, East Lampung, namely: The implementation of learning by applying the STEAM learning approach to the students of the Tribakti Attaqwa Islamic boarding school is a process and effort made by teachers/ustadz to students/students in the Islamic boarding school to be able to find and solve every solution to each problem (problem Solving) learning that is carried out. Based on an interview with the head of the Tribakti Islamic Boarding School Leadership Attaqwa KH. Khaliq Amrullah Adnan stated that "at the Islamic Boarding School we have been applying a classical learning approach, which in the classical learning process still adheres to traditional learning strategies in the form of ustadz reading the yellow book, students/students listening, translating the books. At another time after the learning process is completed, the students/students conduct a deliberation to discuss the study of the book that has been translated by the previous ustadz, this learning process is guided by the students/students in the

term of the rois pesantren, the rois is the student who is responsible for one book to retranslate the results of the translation of the ustadz at the time of the previous lesson, then discuss questions and answers related to the learning material".

Still according to KH. Khaliq Amrullah Adnan stated "after conducting an FGD with researchers (Dr. Mualimin, M.Pd.I and Dr. Ade Imelda Frimyanti, M.Pd.I) during the initial observation at our Islamic boarding school by introducing the STEAM learning approach, in our opinion there are similarities with the classical learning approach that we have applied at the Tribakti Attaqwa Islamic Boarding School, so we think this STEAM learning approach needs to be applied at the Tribakti Attaqwa Islamic Boarding School without eliminating the classical learning identity that 0074 already exists, but collaborating the STEAm learning approach with classical learning.

In addition, according to Maria Ulfatul Jannah, the use of a STEAM-based learning approach at the Tribakti Attaqwa Islamic Boarding School has not been implemented because the facilities and infrastructure are inadequate, but my little knowledge about STEAM learning at the Tribakti Attaqwa Islamic Boarding School is very appropriate, because it is able to create active, creative, and fun learning and make students/students become independent in the learning process, students/students will be more free to develop creativity and imagination". In addition, Maria Ulfatul Jannah as the Vice President of Student Affairs also added that through STEAM learning, it can also develop six aspects of development in students, including: aspects of religious and moral values, language aspects, social-emotional aspects, physical motor aspects, art aspects, and most importantly cognitive aspects.

The results of the research were obtained through direct observation of the implementation of STEAM-based learning, interviews with related parties, and document collection. The following are the findings and processes carried out by teachers/ustadz in the application of STEAM-based learning to students/students of the Tribakti Attaqwa Rama Puja Raman North Islamic boarding school, East Lampung. Based on the results of an interview with Agus Nasrullah as the head of Madrasah of the Tribakti Attaqwa Rama Puja Raman North Islamic Boarding School, East Lampung, that before starting learning, teachers plan learning activities first. In this case, teachers focus more on learning

outcomes, so that children's abilities are obtained through the internalization of knowledge, attitudes, skills, competencies, and the accumulation of work experience. (Interview, October 12, 2024). A similar statement was conveyed by Mr. Rommy Nurfauzi that in the implementation of learning, teachers/ustadz first prepare learning tools as a reference for teachers/ustadz in the learning process so that learning achievements can be achieved. (Interview, October 12, 2024)

Based on the results of observations made by the researcher, at the Tribakti Attaqwa Islamic Boarding School before the implementation of ustadz/teacher learning, referring to learning tools such as learning implementation plans (RPP), weekly learning implementation plans, semester programs and annual programs, in the learning implementation plan applied the STEAM learning approach. This explanation is strengthened by the results of the documentation obtained, that the ustadz/teachers of the Tribakti Attaqwa Islamic Boarding School did make a learning implementation plan (RPP), a weekly learning implementation plan, a semester program and an annual program (Documentation, October 21, 2021). Based on the results of the interviews, observations, and documentation above, it can be concluded that the ustadz/teachers at the Tribakti Attaqwa Raman Utara Islamic Boarding School made a learning implementation plan (RPP), a weekly learning implementation plan, a semester program and an annual program. The learning rank is a reference for the ustadz/teachers who are in the Islamic Boarding School in the learning process, so that the learning process is in accordance with the expected learning outcomes.

Learning Steps

1) **Introduction**
   - The teacher asks the students questions, such as: "Why do we have to maintain cleanliness in Islam?" or "What does thaharah mean in Islam?"
   - The teacher gave a brief explanation of the taharah and the importance of maintaining cleanliness in the teachings of Islam, as well as how it relates to physical and spiritual health.
   - Show a short picture or video that shows how the human body works, including how germs can multiply on a dirty body and how thaharah can help prevent it.

2) **Core Activities**
   - The teacher explained that taharah in Islam includes ablution, big baths (junub), and tayammum.
   - Explain how maintaining personal hygiene can reduce the risk of infection and improve the overall health of the body.
   - The teacher practices ablution correctly in front of the class. Students can follow these steps and pay attention to the details that must be done to ensure that ablution is done correctly.
   - Discuss with students the importance of washing hands, face, and feet in daily life

3) **Concluding**
   - The teacher provides brief feedback on the student's performance during the activity. Do they understand and can practice the taharah correctly
   - The teacher concludes the subject matter that has been discussed and discussed with the students.
   - The teacher gives the task of recording and describing the process of ablution and junub bathing at home, as well as writing a brief report about their experience of performing taharah and how it affects their feelings.

4) **Assesment**
   a. **Formative Assessment**
      - Observation during the practice of ablution and tayammum.
      - Short quizzes or oral questions to test students' understanding of the taharah.
   b. **Summative Assessment:**
      - The individual's task is to describe the steps of taharah (ablution and junub bath) and report their experiences.
      - Creative assessment of the artwork (e.g., posters or drawings of ablution steps).

2. **Application of STEAM STEAM Learning**

At the beginning of the implementation of STEAM learning at the Tribakti Attaqwa Islamic Boarding School, the principal and leaders of the Islamic boarding school held a socialization of STEAM learning to the asatidz/teachers and students/students. Furthermore, teachers hold

STEAM learning training activities directly by rewarding students/students, this is given so that students/students are interested in participating in STEAM learning. STEAM Learning for students/students is learning that discusses material about thaharah using STEAM learning steps without changing classical learning, where the assessment is taken from the learning process rather than on the final learning outcome.

The above statement is strengthened from the results of an interview with Mr. Rommy Nutrfauzi as the vice curriculum officer of MA Tribakti Attaqwa stated "After we received input and FGD together with the researcher at the beginning of observation on September 29, 2024, we felt that STEAM learning was very helpful for us in the learning process at the Trinakti Attaqwa Islamic Boarding School, especially the application of STEAM without eliminating the classical learning system. The same thing was expressed by Mrs. Puji Lestari as a teacher of MA Tribakti Attaqwa that "STEAM learning introduced by the researcher to us teachers/ustadz councils at the Tribakti Attaqwa Islamic Boarding School, we felt interested and tried to apply, after the implementation of STEAM this really helped us in simplifying the learning process with the theme of thaharah by the way we played vedieo related to the practice of thaharah procedures.

Based on observations, information was obtained that the implementation of STEAM learning was quite good, this is because the learning method is adjusted to the classical learning model where ustadz/teacher and santri/student are the center of the learning implementation process. The students/students listen and carry out activities according to what the teacher has shown. This learning model is actually not suitable when applied in STEAM learning, but due to limited facilities and infrastructure and lack of human resources (Human Resources), teachers still use the classical learning model.

A similar statement was delivered by Mr. Junaidi Abdillah stating "In the process of implementing STEAM learning is going well, although we still do not have adequate facilities and infrastructure to support STEAM learning, but the implementation is still going well. (Interview, October 21, 2024). Based on the results of observations, the above interview concluded that the implementation of STEAM learning at the Tribakti Attaqwa Rama Puja Raman North Islamic Boarding School in East

Lampung was very effective, the teachers were enthusiastic in implementing STEAM learning, as well as students/students followed the STEAM learning process carefully and attentively.

3. **Connecting Factors in the Implementation of STEAM Learning.**

a. The low Human Resources (HR) is one of the obstacles to the initial implementation of STEAM learning. At first, STEAM learning at the Tribakti Attaqwa Islamic Boarding School experienced difficulties because many ustadz/teachers still did not understand and know what STEAM learning was.

b. The process of making a learning plan takes quite a long time, because teachers are asked to integrate STEAM learning and without changing classical learning in one lesson which sometimes makes STEAM learning a little difficult.

c. Lack of understanding of students/students about STEAM learning, so teachers and parents sometimes find it difficult to apply STEAM learning to students/students.

4. **Supporting Factors for the Implementation of STEAM Learning**

a. The persistence and high enthusiasm built by the principal and leaders of the Tribakti Attaqwa Rama Puja Raman North Islamic boarding school in East Lampung to the ustadz/teachers so that this STEAM-based learning can be carried out even though the facilities and infrastructure have not been met.

b. The awareness of ustadz/teachers and students/students of the importance of learning with the application of STEAM is very high.

c. Cooperation and communication are well built between school principals, pesantren leaders, teachers and students/students in implementing STEAM learning so that children are very good.

5. **Teachers' Efforts in Overcoming STEAM Learning Inhibitions**

The leaders, and principals at the North Tribakti Attaqwa Rama Puja Raman Islamic Boarding School continue to strive so that this STEAM learning can be implemented, even though at first they found it difficult because

Human Resources (HR) were still low. However, the principal and pesantren leaders always give enthusiasm and positive energy to all parties from teachers, parents, and foundations so that the implementation of STEAM learning can be applied properly. All school parties are still

Teachers always strive for learning to be carried out well when students/students still do not understand the STEAM learning process. Learning, which was initially only carried out in the STEAM learning step system, was finally evaluated after receiving input from teachers, principals and pesantren leaders. After going through deliberations together with all, finally held STEAM learning but still maintained the classical learning system that had been applied at the Tribakti Attaqwa Rama Puja Raman North Islamic boarding school, East Lampung.

Conclusion

The implementation of STEAM-based learning at the Tribakti Attaqwa Rama Puja Raman North Islamic boarding school in East Lampung is quite good, this is in accordance with the results of observations, interviews, and documentation of the success of STEAM learning that has been carried out, where the ustadz/teachers and students/students need to be encouraged again to be able to carry out and follow STEAM learning as expected. Supporting and Inhibiting Factors of STEAM Learning In the implementation of STEAM learning at the

Tribakti Attaqwa Islamic boarding school, there are still several things that hinder learning, Human Resources (HR) are still lacking and the creation of a learning plan that is quite long, lack of STEAM learning training. The supporting factors for the implementation of STEAM learning at the Tribakti Attaqwa Rama Puja Raman North Raman Islamic boarding school in East Lampung are: Persistence and high enthusiasm built by all ranks of ustad/teachers, school principals, and pesantren leaders, the awareness of ustadz/teachers and students/students of the importance of STEAM learning is very high, cooperation and communication are well built between leaders, school principals, Ustadz/Teacher and Santri/Student. Teachers' efforts in overcoming the inhibiting factors of STEAM learning at the Tribakti Attaqwa Rama Puja Raman North Islamic boarding school, East Lampung, are that teachers always strive for learning to be carried out well when students/students still do not understand the STEAM learning process. Learning, which was initially only carried out in the STEAM learning step system, was finally evaluated after receiving input from teachers, principals and pesantren leaders. After going through deliberations together with all, finally held STEAM learning but still maintained the classical learning system that had been applied at the Tribakti Attaqwa Rama Puja Raman North Islamic boarding school, East Lampung

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