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STEAM-BASED ISLAMIC EDUCATION LEARNING DESIGN TO IMPROVE THE 21ST CENTURY COMPETENCIES OF ELEMENTARY SCHOOL STUDENTS

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ABSTRACT
This study aims to develop and examine the effectiveness of a STEAM-based (Science, Technology, Engineering, Arts, Mathematics) instructional design in Islamic Religious Education (PAI) to enhance 21st-century competencies among elementary school students. The research employed a Design-Based Research (DBR) approach involving 37 fifth-grade students. Data were collected through pretest–posttest assessments, observations, interviews, and questionnaires, and analyzed using mixed methods. Quantitative findings revealed a significant increase in mean scores from 98.38 (moderate category) to 155.89 (high category), with an N-Gain score of 0.62 (moderate to high) and a large effect size (Cohen's d = 3.402). A paired-sample t-test indicated a statistically significant difference ($p < 0.05$) between pretest and posttest results. Qualitative findings demonstrated improvements in students' active participation, creativity, collaboration, communication, and digital literacy, alongside a shift in teachers' roles toward facilitators of learning. The integration of quantitative and qualitative results confirms that STEAM-based PAI learning is effective, contextual, and relevant in fostering 4C skills and digital literacy. This model is recommended as an innovative approach for developing Islamic education curricula at the elementary level.
Keywords: Islamic Religious Education, Learning Design, STEAM, 21st-Century Competencies

INTRODUCTION

Educational transformation in the Industry 4.0 era demands education that can develop 21st-century skills, including critical thinking, creativity, teamwork, communication, and technological literacy. In the context of Islamic Religious Education (PAI), these skills are increasingly important for students to understand Islamic principles contextually and practically. In other contexts, conventional learning models are still dominant, hindering the development of higher-order thinking skills (HOTS). STEAM (Science, Technology, Engineering, Arts, Mathematics) education is an innovative approach that can enhance students' creativity, digital literacy, and problem-solving abilities. Furthermore, it is necessary to develop an adaptive curriculum and teaching tools based on 21st-century competencies so that the learning process runs in accordance with learning outcomes. This study is designed to analyze the effectiveness of STEAM-based PAI learning, the development of a STEAM learning model, which will be followed by the development of 21st-century competency assessment instruments.

The 21st century is marked by rapid advances in science, digital technology, and information. Education today must focus more on students' ability to think critically, creatively, collaboratively, and communicate effectively rather than on subject matter alone (Trilling & Fadel, 2009:45). These abilities are known as 21st-century skills, or 21st-century competencies, which are important and must be possessed by students to face globalization and the Industrial Revolution 4.0. The Ministry of Education, Culture, Research, and Technology of the Republic of Indonesia (Kemdikbud RI, 2022:12), through the Merdeka Curriculum, has emphasized the importance of learner-centered and project-based learning, which enables the development of higher-order thinking skills (HOTS). The integration of Science, Technology, Engineering, Arts, and Mathematics (STEAM) is one of the most important factors in achieving this goal. This has the potential to enhance students' critical thinking and creativity. (Bybee, 2013:22).

In the context of Islamic Religious Education (PAI) in elementary schools, STEAM education has emerged as a strategic tool to encourage integrated learning between religious and modern sciences. Until now, PAI education has focused more on cognitive and behavioral aspects, with little emphasis on active participation and creativity among students. However, Islam encourages its followers to think critically and use their intellect in understanding Allah SWT's creation, as stated in QS. Ali Imran [3]:190)

STEAM can be used as a medium for conveying information and knowledge through contextual learning activities. For example, through simple projects such as building a mini eco-mosque, students can learn about hygiene and the environment (science), mosque design (technology and engineering), calligraphy (art), and calculating area (mathematics) related to Islamic Religious Education. This type of learning not only improves students' cognition but also their affective and psychomotor skills (Hidayat & Rahman, 2020:50). Furthermore, research shows that integrating STEAM into basic education can foster a love of learning and interest in science, as well as improve character traits such as discipline, teamwork, and collaboration (Rahmawati & Kurniawan, 2020:27). In the context of PAI, STEAM education is in line with the objectives of Islamic education, namely to foster curiosity, knowledge, and perseverance (Anwar, 2019:67).

Innovative learning is a form of education that focuses on developing higher-order thinking skills through creative and contextual learning strategies, methods, and media. According to Joyce, Weil, and Calhoun (2015:13), innovative learning involves four aspects, namely active student participation, the use of real-world problems as a learning context, the integration of various disciplines, and the use of technology to enhance the learning experience (Marzano, 2017:41). Innovative learning is essential to improve students' 21st-century competencies, which are a set of skills needed to deal with the complexities of the modern world, including critical thinking, communication, collaboration, and creativity (Trilling & Fadel, 2009:45). The Partnership for 21st Century Learning (P21) groups these competencies into three main dimensions. First, Learning and Innovation Skills (4Cs) include critical thinking, communication, teamwork, and creativity. Second, Information, media, and technology skills. Third, Life and Career Skills. In the context of basic education, 21st-century competencies are developed through active, collaborative, and contextual learning. Teachers must equip students with lifelong learning skills by utilizing various digital and non-digital learning resources (Fadel et al., 2015:33).

And in the 21st century, education focuses not only on teaching knowledge, but also on developing the 4Cs: critical thinking, creativity, communication, and collaboration skills. These competencies are important for students to be able to adapt to technological changes, globalization, and complex social issues (Mardhiyah, Aldriani, & Zulfikar, 2024). One of the most effective ways to develop these skills is through STEAM education (Science, Technology, Engineering, Arts, and Mathematics), which enables the integration of disciplines, project-based learning, and the use of seniors as reflective and creative elements.

STEAM is an acronym for Science, Technology, Engineering, Arts, and Mathematics—an interdisciplinary framework that combines these fields into a single integrated learning process. According to Yakman and Lee (2012:35), STEAM not only enhances cognitive abilities in science and mathematics, but also fosters creativity through art and design, and improves problem-solving skills through research and technology. Meanwhile, according to Bybee (2013:22), STEAM education focuses on developing 21st-century skills because it prepares students to become critical thinkers, innovators, collaborators, and effective communicators. STEAM is a teaching strategy that combines the concepts of integrated learning and project-based learning (Rahmawati & Kurniawan, 2020:27). The stages of STEAM learning generally follow the Engineering Design Process (EDP): 1) Ask (identify problems), 2) Imagine (design solutions), 3) Plan (make plans and designs), 4) Create (build or make products), and 5) Improve (evaluate and improve). These stages are in line with the concept of inquiry learning in science and are consistent with the principles of Islamic education, which encourage reflective and exploratory thinking about the creations of Allah SWT (QS. Al-Ghasyiyah [88]:17–20).

The integration of STEAM into PAI aims to foster awareness that science and religion are two complementary things. The Qur'an encourages humans to think, research, and understand natural phenomena. For example, in QS. Yunus [10]:101. This verse shows that scientific observation is part of intellectual worship. Therefore, STEAM learning can be a vehicle for instilling scientific monotheism, namely understanding science as part of recognizing the greatness of Allah (Hidayat & Rahman, 2020:50). The STEAM-based PAI learning model can be improved by incorporating project-based learning techniques. For example, using the theme “Cleanliness is Part of Faith,” teachers can instruct students to create miniature environments: This program improves spiritual, intellectual, and practical skills while developing 4C competencies through teamwork, discussion, and product innovation (Suryani, 2022:61). The results of previous research related to 21st-century competencies and STEAM-based learning include research by Deák & Kumar (2024) entitled A Systematic Review of STEAM Education’s Role in Nurturing Digital Competencies for Sustainable Innovations, which concludes that STEAM greatly contributes to fostering multidimensional digital competencies, not just technical skills, but also critical thinking, collaboration, and the use of technology in a social context. Their NOISE analysis identified the “needs” for pedagogical training for teachers; the ‘strengths’ of STEAM in fostering creativity and innovative thinking; and the “opportunities” for innovation in a sustainable context. Mertala, Fagerlund & Dufva (2024), in their research titled Rethinking the A in STEAM: Insights from and for AI Literacy Education, highlight the importance of “A” (Arts) in STEAM as a crucial element for artificial intelligence (AI) literacy. They argue that the arts (e.g., language, philosophy, visual arts) can be used to explore AI themes such as ethics, bias,

and creative expression, so that students not only understand the technology but also reflect on its social and humanistic impacts. This approach is highly relevant in the context of 21st-century competencies, as it combines creativity, critical thinking, and social awareness. (Kumalasani and Kusumaningtyas : 2022);

21st Century Skills in STEAM-Based Learning Models in Elementary School Thematic Lesson Plans. They examined elementary school thematic lesson plans that used the STEAM approach. They found that these lesson plans contained elements of 4C: critical thinking (40%), collaboration (21%), communication (17%), and creative thinking (22%). This study shows that STEAM-based lesson plans can be systematically directed to foster 21st-century skills through learning model design and activity planning. Evy Nur Rochmah (2024) titled Learning Environments as Support for STEAM to Hone the 21st-Century Skills of Elementary School Students. This article reveals that "learning environments" are a supporting factor for STEAM. According to this study, learning environments designed with a STEAM approach can sharpen the 4C skills of elementary school students (critical thinking, creativity, communication, collaboration). The author states that effective STEAM learning requires structural support (classrooms, materials, technology) so that 21st-century skills can grow optimally. Putri, Wulandari & Febriastuti (2021) with the research title Implementation of the Loose Parts Learning Approach in Developing 21st-Century Skills in Early Childhood. Researchers concluded that the use of loose parts (simple pieces that can be assembled, arranged, and modified) in STEAM has great potential to develop the creativity and initiative of early childhood education students, as well as 21st-century skills such as flexible thinking and collaboration. Loose parts allow children to experiment, solve problems, and create freely, in line with the principles of STEAM and 21st-century learning.

Based on the above literature review, there are several gaps and challenges that need attention in STEAM research and practice related to 21st-century competencies, namely the need for lesson plans (RPP) that apply design thinking or the engineering design process so that learning is not just a project but an iterative thinking process. There is also a need for assessment instruments that can measure not only products but also thinking processes, collaboration, reflection, and creativity. Many studies have not explicitly mentioned the 4C performance assessment rubric in STEAM. Evaluations of the effectiveness of STEAM on 21st-century competencies are still largely qualitative or small studies, so large quantitative studies are needed. Based on the above gap analysis, the researchers see that this study is very important to fill the void and complement previous studies, especially in the aspect of developing a curriculum and teaching modules for lesson plans with explicit integration of STEAM and 4C. The lesson plan must include the phases of design thinking, experimentation, collaboration, reflection, and presentation as a basis for implementing learning. In addition, reference books or teaching materials containing STEAM-based learning are also needed to foster 21st-century competencies for teachers in schools. Furthermore, there is currently no STEAM learning integrated with Islamic Education subjects. This research will also develop student assessment instruments to measure the 4Cs, such as rubrics for collaboration, reflection, creativity, and digital literacy.

Therefore, research related to STEAM (Science, Technology, Engineering, Arts, and Mathematics) learning design in Islamic Religious Education (IRE) is important in the context of 21st-century education. Social transformation, scientific progress, and the development of global competencies have led to the emergence of PAI learning models that

focus not only on the cognitive aspects of education, but also on critical thinking, creativity, collaboration, and problem solving. As an interdisciplinary approach to education that integrates academic knowledge, technology, research, science, and mathematics, STEAM offers significant opportunities to revitalize PAI education to be more contextual, practical, and in line with the needs of today's students. with the following considerations:

First, research on STEAM-based learning design in PAI is important because this approach can enrich values and moral learning by strengthening science and technology literacy. PAI is often considered a normative and theoretical teaching method. In fact, Islamic principles such as trustworthiness, hard work, responsibility, and creativity can be strengthened through project-based learning activities, experiments, and problem-solving exercises. Higher Order Thinking Skills (HOTS) and STEAM integration enable students to study Islam more effectively. Therefore, research on STEAM-PAI learning models, strategies, and approaches is essential to ensure that teachers have valid and applicable operational guidelines in the classroom. Second, the importance of this research lies in its contribution to the relevance of the PAI curriculum in responding to the challenges of the digital age. The education system is moving towards a paradigm that emphasizes 4Cs (critical thinking, creativity, communication, and collaboration). Without innovation in PAI education, there is a possibility that the objectives of the national curriculum and school-based learning will differ. Through STEAM-based educational design studies, educators can develop PAI learning models that integrate technology (such as digital media, science simulations, or simple engineering) as well as visual and creative elements to enhance understanding of religious concepts. Third, this research is very important for advancing evidence-based practice in Islamic education. Currently, there are many conceptual innovations in PAI learning that have not been empirically tested. Design-Based Research (DBR) enables the systematic development of learning processes, from problem analysis, planning, expert validation, limited trials, to comprehensive revisions. The findings of this study produced a theoretically and empirically valid STEAM-based PAI teaching model or module. This is an important contribution for educators, teachers, and decision makers in developing PAI based on innovative principles. Fourth, the STEAM learning design in PAI can contribute to improving students' 21st-century competencies, particularly digital literacy, scientific literacy, creativity, and collaborative skills. In the context of PAI education, these competencies not only promote academic success but also foster the development of students' personalities so that they can adapt to changing circumstances and even apply Islamic values in modern life. STEAM research in the field of Islamic religious education can provide evidence that integrating religious and general education can result in more comprehensive and meaningful learning. Therefore, research on STEAM-based learning design in Islamic education is becoming increasingly important. In addition to encouraging learning innovation, this research also contributes to strengthening 21st-century competencies, increasing curriculum relevance, developing character based on Islamic values, and revitalizing Islamic scientific traditions through interdisciplinarity. The findings of this research are expected to become the basis for developing a more creative, contextual, and future-oriented PAI learning paradigm.

The main objective of this research is to develop innovative STEAM-based learning designs for PAI subjects in elementary schools and to measure the effectiveness of STEAM-based learning in improving students' 21st-century competencies, especially critical

thinking, creativity, collaboration, communication, and digital literacy, as well as to enrich scientific knowledge in the field of Islamic education and modern learning theory, provide alternative creative and contextual learning models for PAI teachers, and serve as the basis for developing an integrative project-based curriculum that does not abandon spiritual values.

RESEARCH METHOD

This study uses a Design-Based Research (DBR) approach for research and development. This approach was chosen because it is suitable for achieving and improving the effectiveness of innovative STEAM-based learning designs used in Islamic education. According to Wang and Hannafin (2005:6), Design-Based Research is a method that aims to improve practical solutions to educational problems through collaboration between researchers and practitioners in the field. This approach combines theoretical and empirical studies with development (planning and implementation of learning models). The goal of DBR is to produce not only empirical findings, but also valid, effective, and applicable learning designs for elementary schools (Plomp & Nieveen, 2013:15). The subjects of the study were Islamic education teachers and students. The research object is innovative STEAM-based learning designs and students' 21st-century competencies, which include four main indicators: critical thinking, creativity, collaboration, and communication. The research procedure adapted the Design-Based Research model (Wang & Hannafin, 2005:7), which consists of four main stages as follows:

First, the analysis and problem identification stage. At this stage, the researcher conducted a preliminary study through classroom observation and interviews with PAI teachers to identify learning problems, such as the lack of integration of Islamic values with science and the low level of critical thinking among students. This analysis also includes a review of the PAI curriculum and textbooks. Second, the design stage: the researcher develops an innovative STEAM-based learning design that includes: mapping PAI competencies that can be integrated with STEAM elements, developing a project-based learning scenario with the steps Ask–Imagine–Plan–Create–Improve. Development of learning tools: teaching modules/lesson plans, and simple digital learning media. The initial design was validated by elementary education experts using an expert judgment sheet. Third, the implementation stage, where the learning design was tested in fifth-grade elementary school classes in two PAI learning sessions with the theme “Cleanliness is Part of Faith.” Teachers conducted project-based learning on the creation of a simple eco-wudhu station. The learning activities involved the following elements: (1) Science: understanding the concepts of clean water and hygiene. (2) Technology & Engineering: creating a simple filtration system. (3) Art: decorating and designing a miniature wudhu (ablution) facility. (4) Mathematics: calculating water volume and usage efficiency. (5) PAI: understanding hadiths about cleanliness and spiritual responsibility. Fourth, the evaluation and reflection stage. After implementation, researchers and teachers reflect together on student learning outcomes and the effectiveness of the learning design. Data is obtained through observation, interviews, and 4C skills assessment. The results of the reflection are used to revise the learning design to make it more effective and easier to apply in other context

Data collection techniques used several complementary instruments, namely: 1) Observation to see the activities of teachers and students during learning, including

collaborative interactions, creativity, and communication. 2) Interviews were conducted with teachers and students to explore learning experiences and perceptions of the STEAM model, student satisfaction and interest. And 3) tests and questionnaires to measure students' 21st-century skills and the effectiveness of STEAM-based learning. The instruments used include: Observation sheets for student and teacher activities, containing indicators of 4C activities. STEAM product assessment rubrics, covering creativity, function, and aesthetics. Structured interview sheets for teachers and students. Critical thinking ability tests, based on the indicators of analyzing, evaluating, and creating (Brookhart, 2010:62). The validity of the instruments was tested through expert judgment for the interview and observation guidelines, while for tests and questionnaires, validity and reliability tests (Cronbach's Alpha) were used. The data analysis technique used is a mixed methods approach, which combines qualitative and quantitative analysis in a complementary manner. Qualitative data (observations, interviews, reflections) were analyzed using reduction, categorization, and conclusion drawing techniques (Miles, Huberman, & Saldaña, 2014:31), while quantitative data (test and questionnaire results) were analyzed using descriptive statistics and N -Gain Score to see changes in student competency before and after the model was implemented.

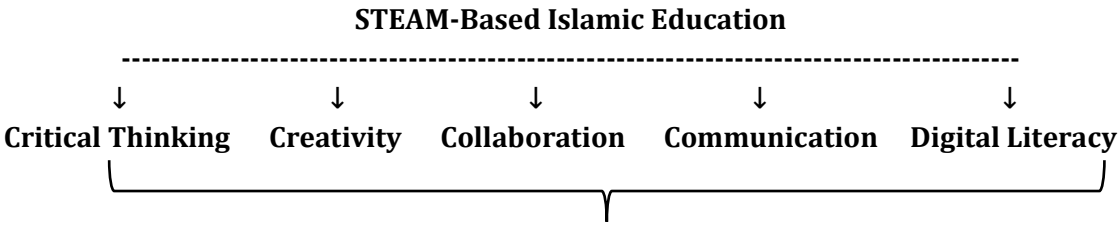

Figure 1.
Research Design

RESULTS AND DISCUSSION

This study aims to determine the effectiveness of innovative STEAM-based PAI learning designs in improving the 21st-century competencies of elementary school students. The research subjects consisted of 37 fifth-grade students. Data were obtained through pretest and posttest questionnaires, interviews with students and teachers, and learning observations. The analysis was conducted using a quantitative approach (descriptive and inferential statistics) and a qualitative approach using the Miles & Huberman analysis model. Based on the results of the pretest and posttest, after analysis using statistics, the following data was obtained:

Statistik	Nilai Pre_test	Nilai Post_test
Mean	98,38	155,89
Median	96	154
Modus	82	158
Standar Deviasi	39,37	23,8
Minimum	40	120
Maksimum	160	198

Based on the results of the pre-test calculation, it can be seen that the average score of 98.38 falls within the range of 88–112, which is in the Moderate category. This means that before the implementation of STEAM-based learning, students' 21st-century competencies were at a moderate level, not yet optimal, but already had a basic level of ability. The standard deviation of 39.37 indicates a fairly large variation in scores. This means that there are significant differences in ability among students. Some students have very low scores, while others have very high scores. Based on the median value (96) which is close to the mean (98.38), this shows that the questionnaire results are normally distributed. Meanwhile, based on the mode value (82) which is in the low category, this shows that quite a number of students are still at a low level of competency. Therefore, based on the results of descriptive statistical analysis of the pretest data, it can be concluded that, in general, the 21st-century competencies of students before the implementation of STEAM-based learning were in the moderate category. The minimum score of 40 and maximum score of 160 with a range of 120 show that there is a wide variation in ability among students. This is reinforced by the high standard deviation of 39.37, indicating that the level of mastery of 21st-century competencies is not yet evenly distributed; there are students who have shown relatively good abilities, However, many are still at a low level. Substantively, this condition illustrates that prior to learning intervention, students' critical thinking, creativity, collaboration, communication, and digital literacy skills have not developed optimally and still require more appropriate learning strategies to encourage more equitable and significant improvement.

Based on the post-test results, the average score was 155.89, falling within the range of 151.2–166.8, which is classified as Moderate (tending towards high). However, in practical terms, this score is very close to the High category, indicating a significant improvement compared to the pre-test results. The standard deviation of 23.80 is smaller than that of the pretest (39.37), which means that the variation in scores between students is smaller, students' abilities are more evenly distributed, and there are no longer extreme gaps as in the pretest. This shows that STEAM-based learning not only increases the average but also makes students' competencies more homogeneous at a higher level. The median (154) is very close to the mean (155.89), which means that the data distribution is relatively normal. The mode (158) is in the Medium to High category. These findings show that STEAM-based learning is not only effective in improving the average critical thinking, creativity, collaboration, communication, and digital literacy skills, but also in reducing the gap in abilities among students. The implication is that this learning model is worth recommending as a strategic approach in PAI learning in elementary schools because it has been proven to encourage more inclusive, participatory learning that is oriented towards the continuous development of 21st-century skills. Implications. To determine the effectiveness of STEAM-based PAI learning, Gain Score (N-Gain) is used with the following formula:

$$\text{N-Gain} = \frac{\text{Skor Posttest} - \text{Skor Pretest}}{\text{Skor Maksimal} - \text{Skor Pretest}}$$

Nilai N-Gain	Kategori
< 0,30	Rendah
0,30 – 0,70	Sedang
> 0,70	Tinggi

Based on the N-Gain calculation result of 0.577, which is in the moderate category, it can be interpreted that STEAM-based PAI learning provides a fairly effective improvement in students' 21st-century competencies. Conceptually, N-Gain measures the effectiveness of improvement by considering the initial score (pretest) and final score (posttest), so that the number 0.577 indicates that more than half of the maximum potential improvement that students could achieve has been realized through learning intervention. This means that learning not only resulted in a numerical increase in scores, but also showed substantive changes in the development of critical thinking, creativity, collaboration, communication, and digital literacy skills. This moderate category indicates that the STEAM model has worked effectively, although there is still room for further optimization, for example through strengthening project assistance, differentiating tasks according to student abilities, or deeper technology integration. Thus, these N-Gain results confirm that STEAM-based learning is worth maintaining and developing as a strategy for continuously improving 21st-century competencies. And to determine the effect and its magnitude, a paired t-test and effect size (Cohen's d) were used with the following formula:

$$d = \frac{M_1 - M_2}{SD_{pooled}}$$

Nilai d	Interpretasi
0,2	Kecil
00.50	Sedang
0,8	Besar
> 0,80	Sangat Besar

The paired t-test results show a t-value of 20.691 with a significance level of $p < 0.05$, indicating a significant difference between the pretest and posttest scores. The N-Gain analysis produced an average value of 0.62, which is in the moderate to high category. In addition, the effect size (Cohen's d) value of 3.402 indicates a very large effect. Thus, STEAM-based learning has been proven to be significantly effective in improving students' 21st-century competencies.

The results of the study show that STEAM-based PAI learning significantly improves students' 21st-century competencies. This improvement can be seen from the increase in the average score of 57.51 points, a decrease in standard deviation (more even abilities), significant t-test results, a moderate to high N-Gain category, and a very large effect size. This shows that the STEAM approach encourages critical thinking through problem solving, develops creativity through projects, enhances collaboration in group work, trains communication through presentations and discussions, and strengthens technological literacy through project activities using digital media. Theoretically, these findings support the constructivist and student-centered learning approaches that place students as active subjects in learning. Qualitative data was obtained through observation and interviews with students and teachers, then analyzed using the Miles and Huberman model through three main stages, namely: (1) data reduction, (2) data display, and (3) drawing conclusions and verification. The following are the results of qualitative data analysis from interviews and observations of students and teachers:

1. Data Reduction

During the data reduction stage, all interview and observation results from teachers and students were selected, focused, and categorized based on 21st-century competency indicators (4Cs and digital literacy) and the dynamics of STEAM learning

implementation. Data irrelevant to the research focus was eliminated so that the analysis centered on the effectiveness of STEAM-based learning in developing 21st-century competencies. After the data reduction process, it can be explained that the main themes that emerged from the students were: first, learning was more enjoyable and easier to understand. Second, there was group work and division of tasks. Third, there was an increase in the courage to ask questions and give presentations. Fourth, the creation of creative products (eco stations). Fifth, the use of technology to search for information. Meanwhile, the main themes identified by teachers were: 1) A change in the role of teachers to become facilitators. 2) Students are more active and participatory. 3) Class discussions are more lively. 4) Creativity and collaboration have increased. 5) Challenges in time management and technological readiness.

2. Data Display

The reduced data was then presented in the form of a thematic matrix to see the patterns of correlation between teacher and student data.

Aspect	Student Findings	Teacher Findings	Observations
Critical Thinking	Frequently asks questions & seeks solutions	Students are more reflective	Active and argumentative discussions
Creativity	Creating product	Product results are varied	Works result show originality
Collaboration	Sharing tasks & helping each other	Teamwork is more effective	Group interaction runs well
Communication	More courageous in presentations	Students are more confident	Presentations appear more systematic
Digital Literacy	Using cell phones/laptops	Technology supports learning	Digital media is used to help with assignments.

Based on the data display, there is consistency between the perceptions of students, teachers, and direct observations in the classroom.

3. Conclusion and Verification

Based on the reduction and presentation of data, it can be concluded that STEAM-based PAI learning has a positive impact on the development of students' 21st-century competencies. Students showed increased participation, creativity, ability to work together, and courage to communicate. Teachers also experienced a change in their role from the center of learning to facilitators who provided space for exploration. Classroom observations reinforced the interview results, showing that the changes felt by teachers and students were truly evident in learning practices. Despite technical obstacles such as time management and technological readiness, the implementation of STEAM was generally effective and systematic. The verification process was carried out through triangulation between student interview data, teacher interviews, and observations, which showed consistency and mutual reinforcement. Based on Miles & Huberman's model analysis, it can be concluded that: First, STEAM-based PAI learning has

successfully changed the learning pattern to be more student-centered. Second, 21st-century competencies (4Cs and digital literacy) have developed significantly and are integrated. Third, collaboration and creativity are the most dominant aspects that have improved. Fourth, communication skills and critical thinking skills have begun to develop. Fifth, interview and observation data show consistency in findings, confirming the validity of the data. Thus, the results of the qualitative analysis reinforce the quantitative results that STEAM-based learning is effective in improving the 21st-century competencies of elementary school students.

The results of this study indicate that the implementation of STEAM-based learning in Islamic Religious Education (IRE) has a significant impact on improving the 21st-century competencies of elementary school students. These findings were obtained through quantitative and qualitative analyses that complemented and reinforced each other. Quantitatively, the pretest results show that the level of students' 21st-century competencies before the implementation of STEAM-based learning was in the moderate category. The mean pretest score was in the "fair" category, with a relatively homogeneous data distribution as indicated by a relatively small standard deviation. The minimum and maximum scores show variations in student abilities, but in general, they do not yet demonstrate optimal mastery of the 4C indicators (critical thinking, creativity, collaboration, and communication). This indicates that before the learning intervention, students' abilities were still in the early stages of development and required more contextual, integrative, and learner-centered learning strategies. After implementing STEAM-based learning, the posttest results showed a significant improvement. The average score increased to the "good" category and approached "very good," with the median and mode also rising consistently. This improvement is reinforced by the results of inferential tests (paired t-tests) which show a significant difference between pretest and posttest scores. Thus, it can be statistically concluded that STEAM-based learning is effective in improving students' 21st century competencies. The increase in scores is not only numerical, but also reflects changes in the quality of critical thinking skills, creativity in completing project tasks, the ability to work together in groups, as well as courage and clarity in communication.

These quantitative findings were reinforced by qualitative research results obtained through interviews and observations. Based on analysis using the Miles and Huberman model (data reduction, data presentation, and conclusion drawing), several main themes were obtained. First, teachers felt that the classroom dynamics had become more active and participatory. Students no longer just passively receive material, but are involved in exploration, discussion, and project-based problem solving. Second, students stated that learning felt more enjoyable because they could learn while creating work, discussing with friends, and presenting the results of group work. Third, observations showed an increase in interaction between students, the emergence of creative ideas, and the courage to express opinions.

In the context of critical thinking, students began to get used to asking questions, relating PAI material to everyday life, and seeking solutions to problems given in learning projects. In terms of creativity, this was evident in the variety of products produced by students, such as posters on moral values, simple science-based mini-projects integrated

with Islamic values, and group presentations that demonstrated conceptual understanding. The aspect of collaboration is evident through a more structured division of tasks and shared responsibility in completing projects. Meanwhile, the aspect of communication develops through oral presentations, group discussions, and joint reflection at the end of the learning process. Quantitative and qualitative data show consistent results. The increase in questionnaire scores is in line with direct observations in the classroom and statements from teachers and students. This reinforces that the STEAM approach, which integrates Science, Technology, Engineering, Arts, and Mathematics in the context of PAI learning, is capable of creating meaningful learning experiences. Learning is not only oriented towards knowledge transfer, but also towards the formation of higher order thinking skills. Theoretically, these findings are in line with the constructivist paradigm, which places students as active subjects in constructing knowledge. STEAM provides space for students to experience, explore, and reflect on learning through real projects. In addition, the results of this study also support the concept of 21st-century learning, which emphasizes the importance of 4Cs as core competencies in facing global challenges.

The pedagogical implications of this study indicate that PAI teachers need to develop integrative and innovative learning designs. The use of contextual projects, cross-disciplinary integration, and the provision of space for creative exploration have been proven to improve the quality of the learning process and outcomes. The implementation of STEAM in the context of religious education also proves that Islamic values can be taught in a modern way without losing their spiritual and moral essence. Thus, STEAM-based learning is not only statistically effective, but also pedagogically and contextually relevant in shaping students who are competent, creative, collaborative, communicative, and have good critical thinking skills. Based on the results of research and experiments on STEAM-based learning models in Islamic Education subjects to improve 21st century competencies in elementary school students, the learning model can be described as follows:

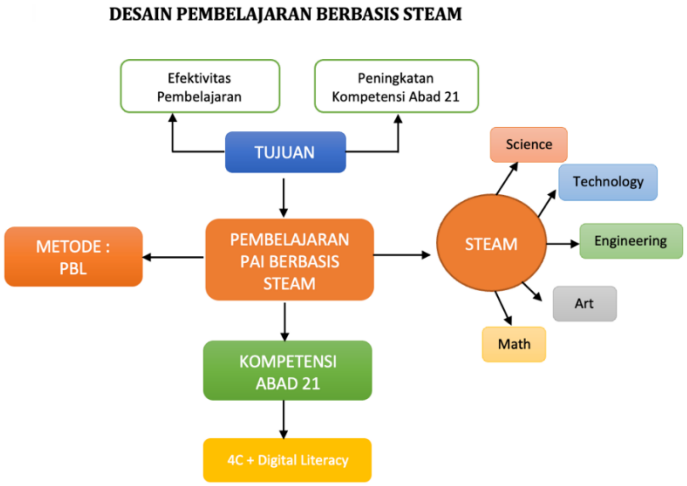

Figure 2.
Learning Model

CONCLUSION

Based on the results of the research and discussion described above, it can be concluded that STEAM-based learning in Islamic Religious Education subjects significantly improves the 21st-century competencies of elementary school students. Quantitatively,

there was an increase in the average score from the moderate category in the pretest to the good category in the posttest, which was reinforced by the results of inferential statistical tests showing significant differences. Qualitatively, there were positive changes in learning dynamics, student participation, and the development of critical thinking, creativity, collaboration, and communication skills.

The integration of quantitative and qualitative data shows that STEAM is not merely a methodological approach, but rather a learning paradigm capable of creating meaningful, contextual learning experiences oriented toward the development of 21st-century competencies. Therefore, STEAM-based learning is recommended as an innovative model in the development of PAI curriculum and learning practices in elementary schools. Overall, this study confirms that the transformation of learning towards an integrative and 21st-century competency-based approach is an urgent need in the world of education. Teachers do not only play a role as conveyors of material, but also as facilitators who guide students to think, create, collaborate, and communicate effectively in facing the challenges of the times.

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