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## STEAM-Based Learning for Mechanical Engineering

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**Abstrak:** Penelitian ini bertujuan untuk mengimplementasikan pembelajaran berbasis STEAM (Science Technology, Engineering Art Mathematics) pada program studi sarjana teknik mesin di Universitas Sebelas Maret. Mengintegrasikan pembelajaran STEAM pada mahasiswa teknik dalam pengembangan desain dapat meningkatkan pemahaman mahasiswa tentang teknik mesin melalui proyek, tantangan, dan pencapaian. Artikel ini berfokus pada bagaimana mengintegrasikan proyek pembelajaran ke dalam area berbasis pembelajaran dan mengevaluasi sejauh mana pemahaman mereka. Dalam artikel ini digunakan pendekatan deskriptif. Pendekatan ini bertujuan untuk menjelaskan suatu fenomena atau realitas sosial dengan cara mendeskripsikan variabel-variabel yang berkaitan dengan subjek dan unit analisis. Sebanyak 33 mahasiswa jurusan teknik mesin menjadi populasi dalam penelitian ini. Penelitian ini bertujuan untuk memberikan gambaran tentang efektivitas proses pembelajaran berbasis STEAM yang diterapkan pada topik desain proyek melalui penelitian deskriptif. Data menunjukkan bahwa pembelajaran telah meningkat, dan mahasiswa sekarang mempelajari lebih banyak kasus dan secara aktif mendapatkan pengetahuan dibandingkan sebelumnya. Rincian lebih lanjut tentang topik ini dibahas dalam artikel ini.

**Kata kunci :** *STEAM, Teknik mesin, Proyek desain, Pendekatan deskriptif*

**Abstract:** This study aims to implement the STEAM (Science Technology, Engineering Art Mathematics) based learning in the bachelor of mechanical engineering at the Universitas Sebelas Maret. Integrating STEAM learning in engineering students in design development improves students' understanding of mechanical engineering through projects, challenges, and milestones. This article focusses on how to integrate instructional project into learning-based area and evaluate how far their understanding of. In this article a descriptive approach was used. It aims to explain a phenomenon or social reality by describing variables related to a subject and unit of analysis. 33 university students studying mechanical engineering formed the study population. This study aims to provide an overview of the effectiveness of the STEAM-based learning process applied to the project design topic through descriptive research. The data indicate that learning has improved, and students are now learning more cases and actively gaining knowledge than in the past. Further details about the topic are discussed in this article.

**Keywords:** *STEAM, Mechanical engineering, Project design, Descriptive approach*

## INTRODUCTION

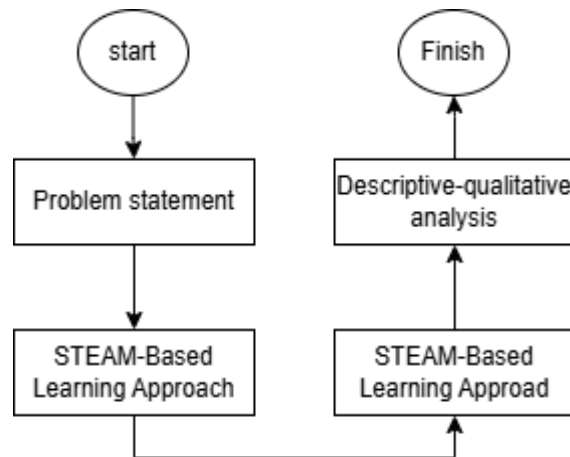
STEAM-based learning presents both opportunities and challenges in mechanical engineering education. It offers an integrated approach to teaching engineering mechanics, connecting competencies across disciplines, and enhancing student engagement (Montés et al., 2022). Through hands-on projects and challenges, students develop problem-solving skills and apply theoretical knowledge to practical scenarios (Almaguer et al., 2020). This approach fosters the development of transversal competencies such as collaboration, critical thinking, and innovation alongside disciplinary skills. The creation of didactic models by students has been shown to facilitate the learning of complex concepts, generate discussions, and increase enthusiasm (Pérez et al., 2018). However, implementing STEAM-based learning can be challenging due to the diverse needs of educational institutions (Conde et al., 2019). Despite these challenges, STEAM-based learning in mechanical engineering has demonstrated potential to better prepare students for the digital world and develop crucial computational thinking skills.

Although there is certainly room for improvement, STEAM-based learning has been shown to have significant benefits for the education of mechanical engineers. It has shown promise in enhancing students' scientific creativity and 21st-century skills. Studies have shown that STEAM courses can significantly improve junior high school students' scientific creativity compared to traditional science courses (Tran et al., 2021). The integration of art, entrepreneurship, and design into STEM education (STEAMeD) has been found to resonate well with the ABET accreditation outcomes and better prepare engineering students for future challenges (Zaher et al., 2023). STEAM-integrated project-based learning models have been identified as effective alternatives to develop critical thinking, problem solving, creativity, collaboration, and communication skills (Zayyinah et al., 2022). Implementing STEAM in 21st-century learning aims to increase students' academic mastery while applying knowledge to daily life, potentially improving cognitive, affective, and psychomotor aspects (Mu'minah & Suryaningsih, 2020). These findings suggest that STEAM-based approaches may be valuable in preparing students for the demands of the modern workforce.

There is a lack of alignment on how to successfully integrate STEAM disciplines, which highlights the research gap. The necessity to adopt STEAM learning at the university level, especially in engineering programmes, in an integrated and coherent manner was also noted. Based on this background, this research aims to explore STEAM (Science Technology Engineering Art Mathematics)-based learning in the Bachelor of Mechanical Engineering.

## RESEARCH METHOD

The approach is mainly based on the descriptive-qualitative method. In order to identify STEAM-Based Learning in the university, the subjects were asked to make a project design referring to the parameter. One advantage of the descriptive analysis is that it avoids the problem of data that cannot count with numeric data, such as the phenomenon of the oh learning style. A total of 33 subjects participated in this study. The procedure of this research can be seen in Figure 1 below:



**Figure 1.** Method procedure

## RESULTS AND DISCUSSION

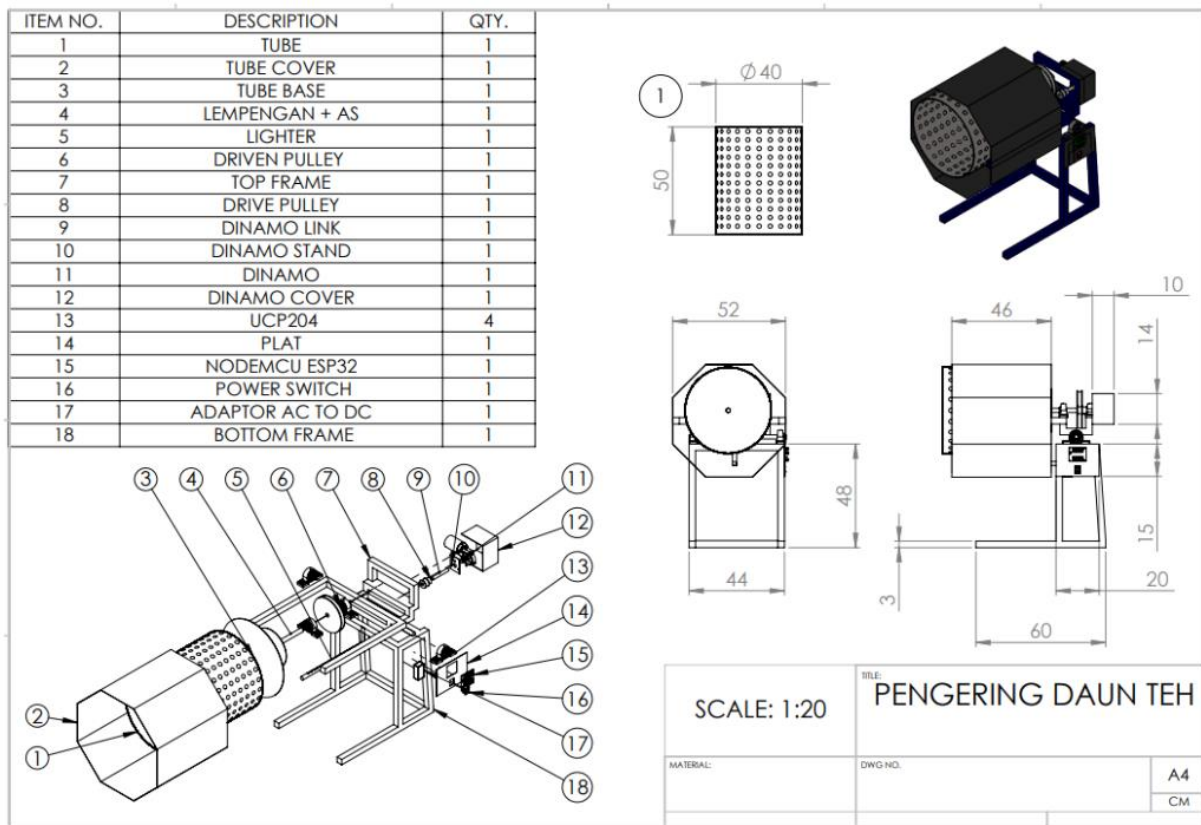
### *Result*

STEAM-based learning has been conducted in mechanical engineering students at the university. The purpose of this study is to investigate the implementation of the STEAM learning approach (Science, Technology, Engineering, Art, and Mathematics) in the Mechanical Engineering majors. The university, which is the reference for research, comes from UNS as a reference for the state campus. Mechanical Engineering is a school that offers specific engineering competencies that allow graduates to master a manufacturing field. This makes it dependent on the role of technology, so there is a great correlation with the methods carried out. This proximity to technology is a strong reason why the campus should be the most appropriate place to talk about this approach to learning. The learning process of the project is described as below:

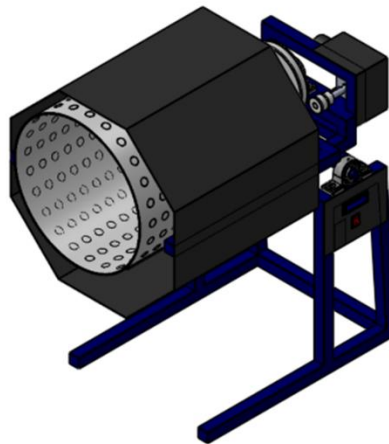
**Table 1.** STEAM activities

Parameter	Activities	Outcome
Science	<ul style="list-style-type: none"> <li>- Create a design project</li> <li>- Create a flow diagram of knowledge-based activities</li> <li>- The concept and theory that support technology</li> </ul>	Machine design report

Parameter	Activities	Outcome
Technology	<ul style="list-style-type: none"> <li>- Manufacturing Tool Design</li> <li>- Components Used</li> <li>- Budget</li> <li>- Functional Test</li> </ul>	Product Design
Engineering	<ul style="list-style-type: none"> <li>- Application of machining competencies</li> <li>- Application of Welding Competencies</li> <li>- Application of finishing and packaging</li> </ul>	Practicum report and how the product works
Art	<ul style="list-style-type: none"> <li>- Design and packaging of machine</li> <li>- Ergonomic</li> <li>- Colour Selection</li> <li>- Component Selection</li> </ul>	Project design proposal
Mathematical	<ul style="list-style-type: none"> <li>- Static Structure Analysis</li> <li>- Load analysis</li> <li>- Connection analyst</li> <li>- Tool Efficiency Analysis</li> </ul>	Computational analysis and simulation



**Figure 2.** Results of the application of Science and Technology in STEAM



**Figure 3.** The results of the application of Engineering and Art in STEAM

**Tabel 2.** Integration results of Mathematical in STEAM

Thermometer (°C)	Sensor (°C)	Average (°C)	Error (%)	Accuration (%)
60,0	60,3	60,52	0,417	99,583
60,0	60,5		0,833	99,167
60,0	60,8		1,355	98,645
61,0	61,1	61,5	0,205	99,795
61,0	61,4		0,615	99,385
61,0	61,6		1,025	98,975
61,0	61,9		1,538	98,462

Calculation formula:

$$\text{Temperature error } 60^{\circ}\text{C} = \frac{|\text{Nilai uji} - \text{Nilai standar}|}{\text{Nilai standar}} \times 100\%$$

$$\text{Temperature error } 60^{\circ}\text{C} = \frac{|60,5^{\circ}\text{C} - 60^{\circ}\text{C}|}{60^{\circ}\text{C}} \times 100\%$$

$$\text{Temperature error } 60^{\circ}\text{C} = 0,9\%$$

### Discussion

According to research, it could be analysed if the student is able to implement all the STEAM parameters. In this case, some highlight activities were discuses. Students are able to focus on jobs and carry out activities according to the necessary parameters, where everything is correlated with each other.

Students are able to distinguish each stage through which they go. Details of each phase of work can also run well. The students have carried out their work according to the questions they want to answer. In relation to art and mathematics, they are inseparable parts of this project. Students can perceive the problem to the maximum. This can be seen from the complete calculations, as well as the artistic touch of packaging that is relevant to the needs of the industry.

The STEAM approach has shown promising results in improving educational outcomes at various levels. At the university level, implementing STEAM in project design improved learning quality, increased lecturer and student activity, and improved student performance (Basri et al., 2023). STEAM-based in projects topic effectively improved students' science literacy skills (Choirunnisa et al., 2023). Integrating STEAM with also conduct in chemistry topic education, which has positively impacted students' science process skills and creative thinking abilities (Mu'minah & Suryaningsih, 2020). Additionally, STEAM acquisition significantly influenced university students' creative and critical thinking skills. These studies collectively demonstrate that STEAM integrated in mechanical projects can be an effective approach to fostering 21st-century skills, enhancing student engagement, and improving learning outcomes across different educational contexts. In summary, these results show that STEAM-based learning is suitable for mechanical engineering.

## CONCLUSIONS AND SUGGESTIONS

Overall, these results suggest that STEAM-based learning is suitable for mechanical engineering. This learning model has improved the quality of student learning. Students can focus on tasks and complete assignments within the required boundaries, where all activities are interrelated. They are also able to identify each stage they go through. However, the presence of teachers is still important. In terms of learning, supervision is carried out to ensure that each implementation process is in accordance with the needs. In the future, this model can be a learning reference suitable for use at university level, especially in mechanical engineering.

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