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Eleven Steps STEAM with Project-Based Learning in Vocational Education

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Abstract

The purpose of this article is to design the application of STEAM (Science, Technology, Engineering, and Mathematics) using a project-based learning approach that is suitable for application in vocational education and to explore how STEAM can improve knowledge, project planning, use technology, and calculate with mathematics towards projects, improving skills for vocational education students. This research uses research and development, and the development model used is the Borg and Gall model. The results of the STEAM design research using the project-based learning approach have resulted in eleven steps. The Eleven STEAM Steps with the Project-Based Learning approach have gone through a validation process carried out by three vocational education experts who stated that the eleven STEAM Steps with the Project-Based Learning approach are valid for use in learning.

Keywords: *project-based learning, STEAM, vocational education, learning models.*

Introduction

STEM education is the foundation for STEAM education. STEM is described as a model that combines science, technology, engineering, and mathematics into educational programs to prepare students for college and develop their talents for the knowledge industries of the future. In STEM education, students are expected to (1) engage in research, (2) develop logical thinking skills, (3) have cooperative abilities, and (4) hone analytical skills (Application for Grants - Sustainability, 2013) In short, STEM education not only focuses on conveying knowledge across disciplines but also emphasizes the student learning process by integrating learning into everyday life. In other words, STEM education not only seeks to integrate various scientific disciplines but also prioritizes interactions between subjects and the relationship between subject knowledge and pedagogical knowledge (Han et al., 2015). The importance of STEM in science education in America is emphasized because educators have the ability to integrate the curriculum with current scientific developments so that students can understand the concepts and finally apply them in real-life situations after going through practice and discussion (Candra et al., 2019)(Mengmeng et al., 2019)(Chang, 2013)

In addition, individuals who have talents in STEM fields tend to develop different

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thinking abilities than individuals who have talents in the arts, who value different perspectives. STEAM education combines these two types of thinking with the goal of cultivating talents capable of cross-integrating disciplines and encouraging creativity. Simultaneously, the STEAM approach fills existing gaps. Therefore, the STEAM approach recognizes the role of the arts in STEM contexts(Lin & Tsai, 2021).(Marín-Marín et al., 2021) also points out that although STEM trains students to.In addition, individuals who have talents in STEM fields tend to develop different thinking abilities than individuals who have talents in the arts, who value different perspectives. STEAM education combines these two types of thinking with the goal of cultivating talents capable of cross-integrating disciplines and encouraging creativity. Simultaneously, the STEAM approach fills existing gaps. Therefore, the STEAM approach recognizes the role of the arts in STEM contexts (Aguayo et al., 2023) (Land, 2013) also points out that although STEM trains students to have strong analytical skills in designing solutions, they also require greater creativity to apply them. In STEAM education, a cross-disciplinary approach is used to enable teachers to teach science, technology, engineering, arts, and mathematics in an integrated manner. In addition, teachers can guide students in absorbing professional knowledge that continues to develop and adapt to rapid changes in society. STEAM emphasizes the importance of analysis in this approach. have strong analytical skills in designing solutions, they also require greater creativity to apply them. In STEAM education, a cross-disciplinary approach is used to enable teachers to teach science, technology, engineering, arts, and mathematics in an integrated manner. In addition, teachers can guide students in absorbing professional knowledge that continues to develop and adapt to rapid changes in society. STEAM emphasizes the importance of analysis in this approach.

STEAM education emphasizes the importance of connecting knowledge from different subjects, discussing existing issues, and finding ways to apply them in real-world situations. Instead of focusing on one particular subject, STEAM education encourages students to learn by combining various subjects and applying a cross-disciplinary thinking approach to solving problems in real-life contexts.

However, there are two similarities between STEAM and STEM (Brown et al., 2021).STEAM education is a model that adopts approaches such as problem-solving and inquiry-based learning with the aim of integrating a variety of subjects. STEAM has shifted from a traditional teacher-centred class form to a more modern one, enabling students to actively find solutions in real-life contexts. In addition, (Yakman, 2008) has conducted previous research and developed theories that analyze and combine various aspects of science, technology, engineering, art, mathematics, and others. These studies show a correlation between the practical content of all subjects and research. Art integration with STEM can create new domains (Yakman & Lee, 2012). In short classify STEM subjects as a coordinated, collaborative, and integrative approach. Although the discipline is integrated, the field goes beyond its boundaries. In this context, STEM developments are beginning to move towards STEAM, an education that combines human and technological aspects, with the aim of building a creative society. In other words, art plays an important role in the exploration and application of cross-disciplinary concepts.

The new focus in educational reform requires the use, creation, and intelligence in developing creativity. As an effort to increase creativity among students, the STEAM approach involves critical processes in creating creativity and innovation. In this process, students can connect existing STEM elements with art practices, design principles, and assessment Key parts of the STEAM approach involve integrated learning methods, which require purpose.

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students can connect existing STEM elements with art practices, design principles, and assessment(Hsiao & Su, 2021). Key parts of the STEAM approach involve integrated learning methods, which require purposeful connections between standards, assessment, and instructional design. STEAM core standards emphasize inquiry and collaboration and highlight project-based learning approaches that incorporate authentic aspects of the arts curriculum (Oner et al., 2016) The teaching method known as project-based learning (PjBL) is designed to give students experiences similar to those in the real world in a structured manner. PBL involves an active classroom approach, which emphasizes learning over a longer period of time and integration between disciplines (Pratiwi & Khotimah, 2022) (Malele & Ramaboka, 2020)The basic concept of PjBL is based on constructivism theory by Piaget and Dewey, which encourages students to face tasks that originate from "real-life" experiences ((Psycharis, 2018)PjBL involves a dynamic classroom approach with an emphasis on long-term learning, cross-disciplinary engagement, and student orientation(Mariana & Kristanto, 2023).ful connections between standards, assessment, and instructional design. STEAM core standards emphasize inquiry and collaboration and highlight project-based learning approaches that incorporate authentic aspects of the arts curriculum (Oner et al., 2016)The teaching method known as project-based learning (PjBL) is designed to give students experiences similar to those in the real world in a structured manner. PjBL involves an active classroom approach, which emphasizes learning over a longer period of time and integration between disciplines).(Bati et al., 2018)The basic concept of PBL is based on constructivism theory by Piaget and Dewey, which encourages students to face tasks that originate from "real-life" experiences PjBL involves a dynamic classroom approach with an emphasis on long-term learning, cross-disciplinary engagement, and student orientation (Oner et al., 2016)

In addition, the PjBL approach to teaching emphasizes contextualized learning, involving complex activities such as giving students the freedom to explore and plan learning activities, work together in collaborative projects, and ultimately produce a product(Adriyawati et al., 2020). Therefore, the incorporation of the STEAM-PjBL method in science learning encourages students to recognize the relevance of scientific knowledge in everyday life situations, develops curiosity and problem solving skills, and increases students' courage to ask questions and search for sources of information (Adriyawati et al., 2020)

Moreover, the PjBL method emphasizes contextualized learning involving complex activities, such as giving students the freedom to explore and plan learning activities, collaborate on joint projects, and ultimately produce a product (Adriyawati et al., 2020)Thus, the integration of the STEAM-PJBL approach in science learning encourages students to understand the relevance of scientific knowledge to events in everyday life, develops curiosity and problem-solving abilities, and increases students' courage to ask questions and investigate various sources of information (Adriyawati et al., 2020)

Meanwhile, in technology and vocational education, the Metal Welding Technology course discusses welding theory and SMAW welding practice. Welding is a process of joining two or more metal parts using heat energy. Students are required to be able to apply shield metal welding techniques. Arc welding is a welding technique that is grouped into welding techniques using arcs and flux. In Project Based learning, students are involved in activities including problem solving, decision making, investigative skills and work skills. Learners should focus on solving problems and questions that help them understand the concepts and principles involved in the project. (Jalinus et al., 2020)Project-Based Learning can increase motivation, improve Shield Metal Arc Welding Technique skills by solving problems, by increasing collaboration within groups and improving resource management skills. Apart from that, Project-Based Learning can improve students' critical thinking skills, creativity, creative thinking abilities and achievement (Jalinus et al., 2022)

In short, education experts have realized that teaching through STEAM provides many benefits for students, covering various arts fields such as social sciences, languages, physics, music, fine arts, performing, and others. Within this framework, students will develop a deeper understanding of the humanities after receiving training in logical thinking. However, compared to the research that focuses on STEAM which has been widely conducted, in vocational education there is still a lack of research related to STEAM. Apart from that, the design of STEAM implementation using the Project Based Learning approach has not been fully developed. Therefore, this research aims to develop a STEAM learning design using a Project Based Learning approach in vocational education that includes technology and paper cutting arts, as well as traditional arts, and then explore the relationship between the skills acquired by students(Gu et al., 2023).

Materials and methods

This research is a type of research and development. Research and development (R&D) with the development model used is Borg and Gall. The validators for the STEAM-based project based learning model are 3 lecturers. The validator verifies 1) the structure of the model and 2) the content of the model. Evaluation of model construction includes aspects: 1) model syntax, 2) social system, 3) response principle, 4) support system, and 5) teaching effect. Content model evaluation includes aspects: 1) content quality and 2) learning quality. Expert validation consists of validation of the construction of the STEAM-based project-based learning model consisting of 20 question items which are used to reveal the construction validation of the STEAM-Based Project-Based Learning Model in Metal Welding Technology and validation of the contents of the STEAM-based project-based learning model consisting of 12 items questions used to reveal the contents of the STEAM-Based Project-Based Learning Model in Metal Welding Technology. Data analysis in this study used Aiken's V to see the validity of the STEAM being designed.

Results

Learning designed using STEAM uses a Project Based Learning approach, lecturers provide students with information and mapping of learning outcomes achieved, as well as the relevance of courses to the real world (industry needs and project assignments on real problems). The lecturer then directs students to familiarize themselves with the module/learning material and leads them in class discussions. So that students understand the concept of learning material by providing information to students and actively participating in discussions about SMAW welding material.

Students are asked to design and conduct research to increase knowledge about SMAW welding. After that, students carry out SMAW welding exercises according to the welding work. Students then conduct research and obtain data, then analyze and interpret the resulting data. Students are able to construct explanations related to the lesson being studied. After that, students can design new solutions to practical SMAW welding problems. Students receive information about the learning that has been completed then evaluate and are able to communicate the results of observations that have been completed and are able to draw conclusions.

This STEAM-based project-based learning model is defined as procedures or steps that researchers must go through so that students can learn, participate and interact with acquired competencies that are oriented towards completing predetermined project tasks. The STEAM-based project-based learning model provides students with the opportunity to develop critical thinking skills in Metal Welding Technology, and with this practice good Skills competencies are achieved. In the STEAM-based project-based learning model, students are also trained and required to make presentations on the lesson material and practical assignments given (Amalu et al., 2023).

Every step there is student interaction in learning and every step in learning will be accompanied by the lecturer who teaches the course. Learning will begin with an introduction to the STEAM teaching system that uses a project-based learning approach, increasing understanding and knowledge with group learning, project planning according to the Metal Welding Technology job sheet, preparing project work schedules, skills training, carrying out project tasks, monitoring, testing and Assessing Results, Evaluation Activities, Organizing students for report presentations and finally Rewards by giving awards to students who have the best understanding and project results.

Tabel 1. STEAM Learning Steps with a Project Based Learning approach

No	STEAM-Based Project-Based Learning Stages in Metal Welding Technology	Student interaction in learning	Role of Lecturer/Tutor/Student Companion
1	Introduction to the STEAM-Based Project-Based Learning Model Teaching System in Metal Welding Technology	Questions and answers about STEAM-Based Project-Based Learning	Learning model direction
	Activities determine Fundamental Questions	Students carry out observations.	Directing students to see SMAW welding applications in the field
2	Organize students in groups and provide learning topics according to the Metal Welding Technology module	Students are divided into several heterogeneous study groups of 3-5 people, and each group receives discussion topics related to the Metal Welding Technology teaching material.	The lecturer divides the participants into several heterogeneous groups and provides discussion topics related to the Metal Welding Technology teaching material
	Students will present the material obtained by each group for 25 minutes	Students who do not do the presentation will ask questions according to the material presented by the presentation group.	The lecturer provides material reinforcement for each presentation group
3	Project planning following the Metal Welding Technology job sheet	Questions and answers about the upcoming project planning	Direction of the planned project
4	Prepare project work schedule Skills Training	Question and answer about the planned project work schedule	The direction of the planned project schedule
5	Skills Training	Students carry out exercises before making a project according to the job sheet	The lecturer provides examples and demonstrations of each project work according to the job sheet
6	Executing the tasks of project	Students work on projects according to the job sheet	Lecturers monitor each student's work

		given	
7	Monitoring	Students will be instructed in project work	Lecturers will monitor student project work
8	Testing and Assessing Results	Students show the results of the projects they have carried out	Lecturers assess the results of student projects
9	Evaluation Activities	Reflection on project activities that have been carried out	The lecturer will provide direction for student project work
10	Organizing students for report presentations	Students present a report on the results of their project work	The lecturer provides material reinforcement from student presentations report
11	Reward		

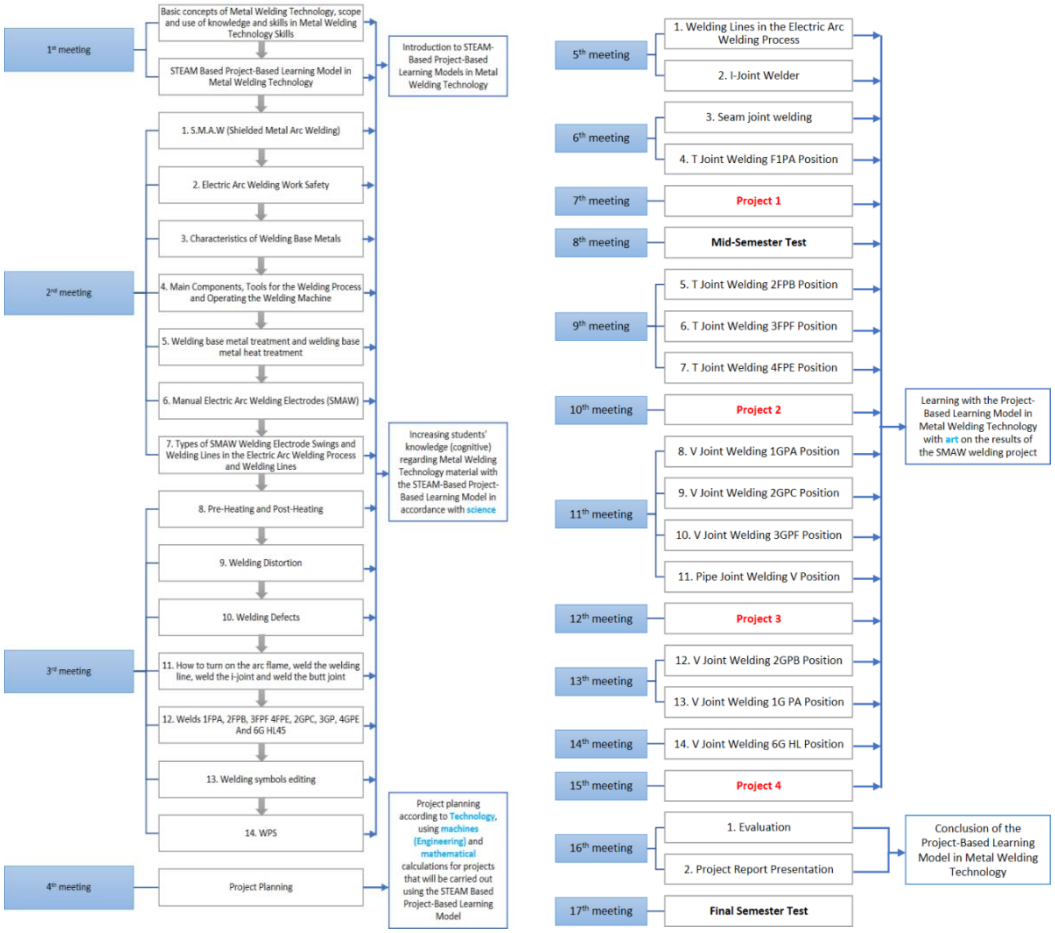

Figure 1. Eleven steps STEAM with PjBL

Next, validation of the construct and content was carried out by three vocational education experts regarding the STEAM design with a Project Based Learning approach based on assessment indicators as in the table:

Table 2. Construct Validity

No.	Indicators	Result of Aiken's V	
1	Syntax Model	0,917	Valid

2	Aspects of Learning Quality	0,833	Valid
3	Reaction Principles	0,917	Valid
4	Support System	0.917	Valid
5	Instructional and Accompanying Impact	0.917	Valid

Table 3. Content Validity

No.	Indicators	Result of Aiken's V	
1	Syntax Model Aspects of Learning Quality	0,917	Valid
2	Syntax Model Aspects of Learning Quality	0,833	Valid

Discussions

This research shows that STEAM using the PjBL approach (Project Based Learning with a Scientific, Technological, Engineering, Arts and Mathematics approach) allows students to improve deduction and induction abilities, as well as logical reasoning abilities in software programming. In addition, this approach helps them strengthen the flexibility and adaptability required in problem solving, so that they can develop communication skills such as in welding activities. Different from regular courses on knowledge delivery, STEAM PjBL educates students to connect knowledge from various subjects, solve problems, and innovate. In this context, students continue to improve their problem-solving abilities, creativity, ethical skills, and innovation abilities. The results of this research support previous findings (Madden et al., 2013) who compared an integrated ethics curriculum and a conventional ethics curriculum, and found that the use of an integrated curriculum was able to increase students' knowledge and trigger students' interest in learning ethics involved in learning through this approach.

There are several recommendations for teaching and practice based on the observations and findings in this study STEAM with the PjBL approach is only limited to vocational education, it is recommended that further research be carried out in general education, for further assessment sheets to be developed in STEAM learning with the PjBL approach so that student competency assessments can be carried out according to the indicators to be achieved.

Conclusions

The conclusion of the research, namely STEAM-based Project-Based Learning in the Metal Welding Technology Course, consists of 11 steps. Learning meetings in one semester consist of 17 meetings namely opening meetings, learning theory strengthening meetings, project planning meetings, practical training meetings, project work meetings, evaluations, mid-semester exams, and final semester exams. The STEAM-Based Project-Based Learning Model in Technology Metal welding is validated by 3 validators. The validator validates 1) Model Construction and 2) Model Content. The validation result of the STEAM-based project-based learning model in Metal Welding Technology is 0.904 or valid. The results of the assessment of the content of the STEAM-based project-based learning model in Metal Welding Technology were 0.903. It is also in valid category.

The weakness of this research is that students must take part from the beginning of the first week of learning to the 17th week of one semester. If students do not take part in one of the lessons, they will not be optimal in learning to improve their knowledge and skills in metal welding technology.

This research concludes that the STEAM-based Project-Based Learning Model is suitable for learning Metal Welding Technology. This model is significant for improving understanding and skills in learning Metal Welding Technology. The novelty in this research is that using the STEAM-based Project-Based Learning Model can increase knowledge, plan projects by currently developing technology, use technology, and calculate mathematically for the projects. Therefore, you can improve skills and improve art in learning Metal Welding Technology.

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