Development of Interactive Tutorial Videos with a Project-Based Learning (PjBL) Approach for Modeling Material in CAD-Assisted Machine Drawing Courses

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Abstract. This study explores the implementation of a CAD-Assisted Machine Drawing course at Universitas Negeri Medan, addressing issues like delayed submissions, low student proficiency in reading drawings, and poor academic performance. The research develops Interactive Tutorial Videos to tackle these challenges using a Project-Based Learning (PjBL) approach for the course's modeling material. Employing the 4-D development model, the study evaluates the validity and practicality of these videos. Results show the videos are highly valid, with a validation score of 0.95%, and practical, with positive feedback from lecturers (91.25%) and students (96.7%). The study concludes that the interactive tutorial videos are effective learning tools for the CAD-Assisted Machine Drawing course

Keywords: Interactive Video; Machine Drawing, Project Based Learning (PjBL), CAD.

1 Introduction

In the ongoing era of globalization and digitalization, the education sector needs to adapt to environmental transformations to remain relevant and effective. In response to these changes, the adoption of digital learning is considered an appropriate solution. Digital learning, which involves the process of education that utilizes technology products as methods and media, plays a crucial role in reinforcing character education. It is not just about motivating students but also about instilling values and ethics. Therefore, the use of technology-based learning media has become an urgent need when considering the current study habits of students [1][2].

Technology has a profound impact on every aspect of our daily lives, changing the way we learn, communicate, seek information, and acquire knowledge. This transformation is not just temporary but will continue to evolve, with increasingly noticeable effects at all levels of the education system. This change presents new challenges for teachers in terms of pedagogy, didactics, and administration, as well as in the development of students' digital literacy, specialized knowledge, and fundamental skills. [3][4].

Technical education plays a crucial role in preparing students to face the challenges of an ever-evolving industrial world. One of the competencies that mechanical engineering students

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must possess is the ability to create technical drawings using Computer-Aided Design (CAD) software. At the Department of Mechanical Engineering Education, Universitas Negeri Medan, the course "CAD-Based Machine Drawing" is a core subject aimed at equipping students with these skills. However, several issues have been identified in its implementation that hinder learning effectiveness. Problems such as delays in submitting assignments, low student proficiency in reading drawings, and unsatisfactory academic performance present challenges that must be addressed promptly. Therefore, there is a need for innovation in teaching methods to enhance student motivation and understanding of the material [5].

One approach that can be adopted to address these issues is Project-Based Learning (PjBL). PjBL is a learning approach that focuses on the learning process through completing real-world projects, which can enhance student engagement and practical skills. In the context of CAD-based machine drawing instruction, the development of Interactive Video Tutorials based on PjBL is expected to be an effective solution for improving the quality of learning [6] [7][8][9], rather than just motivating students to learn, project-based learning facilitates collaboration between instructors. Life skills, which are crucial for tackling everyday problems, are necessary to prepare students in technical education programs for the world beyond campus or the workforce. These skills are gained through students' habits of creating works or solutions that arise from their surrounding environment. Therefore, instructors should develop project-based learning that can enhance students' life skills. The roles of instructors, parents, and the surrounding community are crucial for the success of PjBL. One fundamental issue that is challenging to address is the lack of instructors' ability to develop semester learning plans (RPS) and learning tools due to insufficient knowledge about current technology, leading to limited information and resources being used.

The PjBL (Project-Based Learning) model is highly suitable for project-based subjects and focuses on a product as the final outcome. PjBL is a learning model that involves designing and implementing projects to produce a product. Project-based learning is a student-centered model that provides meaningful learning experiences. Students' learning experiences and conceptual understanding are developed through the products created during the project-based learning process. [10][11].

The course Technical Drawing for Mechanical Engineering is a crucial part of your academic journey, as it aims to provide you with a deep understanding of the fundamental principles of technical drawing in the context of mechanical engineering. The main focus of this course is to teach you the basic skills necessary for technical drawing, which are directly relevant to your future career in the design and fabrication of mechanical components or systems. The curriculum includes fundamental concepts of technical geometry, orthogonal projection, pictorial projection, symbols, and standards in technical drawing. By the end of the course, you will be able to produce accurate and comprehensive technical drawings, depicting construction details, dimensions, and necessary tolerances, thereby inspiring you for your future role in the field of mechanical engineering.

This course may also include an introduction to commonly used computer software in the industry, such as AutoCAD or SolidWorks, to enhance students' skills in producing technical drawings digitally. By applying a practical approach, students are expected to develop their abilities in reading and creating machine technical drawings. Overall, this course is a crucial

foundation for mechanical engineering students, equipping them with the necessary skills for design and production processes in the machinery industry. [12].

Interactive videos based on Project-Based Learning (PBL) emerge as a solution to these needs. PBL-based digital learning media is a form of educational media packaged as interactive multimedia that falls within the category of digital learning using technology in the classroom. PBL-based digital learning media includes educational materials that can be accessed digitally, whether in the form of text, images, videos, or interactive content and can be accessed through mobile devices. The combination of advanced mobile technology and the interactive format of PBL-based digital learning media provides opportunities to enhance student's learning experiences in the Engineering Drawing course [6].

The curriculum for mechanical engineering education requires that students in the Department of Mechanical Engineering Education achieve learning outcomes in the Technical Drawing course by being able to create technical drawings by ISO standards. This involves correctly applying concepts, principles, and procedures within education and society, using technical language that meets industry requirements and the demands of engineering and vocational education. Through this course, students are expected to develop independent learning skills.

This study, which aims to develop and evaluate the validity and practicality of Interactive Tutorial Videos using a Project-Based Learning (PjBL) approach for modeling content in the CAD-Assisted Machine Drawing course, will be conducted using the 4-D development model. This model, which focuses on expert validation and practical feedback from both faculty and students, provides a structured framework for the research. The anticipated results of this study have the potential to significantly improve the quality of education at the Faculty of Engineering, State University of Medan, and serve as a reference for other technical education institutions in developing innovative teaching methods.

2 Method

This study is a type of research and development (R&D). The development model applied is the Four-D Model (4-D), which includes four stages: 1) Define, 2) Design, 3) Develop, and 4) Disseminate. The product resulting from this research is an Interactive Tutorial Video with a Project-Based Learning (PjBL) approach that is valid and practical in supporting the implementation of Independent Learning.

The Interactive Tutorial Video with a Project-Based Learning (PjBL) approach developed was validated by subject matter experts and media experts. It was then tested in Class A of the Mechanical Engineering Education Department at the Faculty of Engineering, Universitas Negeri Medan, during the Even Semester of the 2023/2024 Academic Year, with 38 students. The research instruments used include validation sheets for learning devices and other instruments such as teaching modules, worksheets, learning outcome tests, implementation observation sheets, lecturer response questionnaires, and student response questionnaires. The data analyzed cover the validity and practicality of the Interactive Tutorial Video with a Project-Based Learning (PjBL) approach.

3 Results and Discussion

3.1.Interactive Video Tutorial Development Process Using a Project-Based Learning (PjBL) Approach.

The Define phase is a crucial initial step in developing this teaching module. During this phase, a thorough analysis is conducted on the objectives and constraints of the material, including two-dimensional and three-dimensional drawings and assembly. This process involves establishing and defining the necessary learning requirements. To achieve this, five main steps are carried out: initial and final analysis, learner analysis, concept analysis, task analysis, and formulation of learning objectives. These steps aim to ensure that all aspects of learning are thoroughly considered before moving on to the next phase.

The Design Stage includes several essential steps. First, the interactive tutorial video format was chosen using the Canva Design application. Next, the Interactive Tutorial Video is developed using the Project-Based Learning (PjBL) model format. In this process, the initial design of the video is created with an engaging appearance and easily understandable language. The outcome of this design stage is Draft I, which will then be further developed through validation by experts and testing.

This stage aims to produce an Interactive Tutorial Video using a Project-Based Learning (PjBL) approach that has been updated based on feedback from experts and data obtained from trials. Expert validation is a key criterion for determining the teaching module's feasibility. This evaluation often includes minor notes on sections that need improvement.

Experts validated the teaching module's initial prototype (Prototype I) and used the validation results to revise it and create Prototype II. Subsequently, Prototype II was tested in Class A of the Mechanical Engineering Education Department at the Faculty of Engineering, Universitas Negeri Medan. Data from the trial were analyzed and used for further revisions, resulting in a final teaching module that will be disseminated during the distribution process.

The practicality of the Interactive Tutorial Video with a Project-Based Learning (PjBL) approach was thoroughly tested. Observations were made on its implementation, and feedback questionnaires were collected from both faculty and students. The observations showed that the Interactive Tutorial Video with the Project-Based Learning (PjBL) approach is not just theoretical, but highly practical. Its implementation was rated as fully executed, and feedback from faculty and students categorized as highly practical, with practicality ratings of 95.7% from faculty and 93.8% from students.

At the dissemination stage, the Interactive Tutorial Video with a Project-Based Learning (PjBL) approach is introduced on a limited basis to the lecturers teaching the Machine Drawing course in the Department of Mechanical Engineering Education at the Faculty of Engineering, Universitas Negeri Medan. Additionally, the Interactive Tutorial Video with a Project-Based Learning (PjBL) approach is also introduced to relevant stakeholders.

3.2 Quality of Interactive Video Tutorial Development Using a Project-Based Learning (PjBL) Approach.

Validation by experts was conducted to assess the validity of the Interactive Tutorial Video with a Project-Based Learning (PjBL) approach that has been developed. The results of this

validation are a crucial criterion in determining the feasibility of using the Interactive Tutorial Video with the Project-Based Learning (PjBL) approach. The experts provided feedback with minor notes indicating parts that need improvement.

Overall, the evaluation results from two validators indicated that all components of the Interactive Tutorial Video with the Project-Based Learning (PjBL) approach (Prototype I) were deemed valid, requiring only minor revisions. Based on the experts' recommendations, revisions were made to produce Prototype II, which was then tested. Details of the experts' validation results for the teaching module can be found in Table 1.

Table 1. Description of Expert Validation

Number	Assessment Aspect	Assessment	Category
1	Interactive Video Tutorial Format with Project-Based Learning (PjBL) Approach	0,90	Valid
2	Material presented	0,98	Valid
3	Language	0,96	Valid
4	Time Allocation	0,90	Valid
5	Benefits of Interactive Video Tutorial with Project-Based Learning (PjBL) Approach	1.00	Valid
	Average	**0,95**	**Valid**

The data for the practicality test of Interactive Video Tutorials with Project-Based Learning (PjBL) Approach was taken from a questionnaire that had been distributed to lecturers and conducted at the Department of Mechanical Engineering Education, Faculty of Mechanical Engineering, State University of Medan. This trial aims to see the implementation of learning using Interactive Video Tutorials with a Project-Based Learning (PjBL) Approach. The results of the assessment of the practicality of the Interactive Video Tutorials with the Project-Based Learning (PjBL) Approach are summarized in Table 2 below:

Table 2. Description of the Results of the Data Analysis of Lecturer Practicality

	Assessment Aspects	Assessment Presentation			Category
		D1	D2	Average	
1	Ease of Use of Interactive Video Tutorials with Project-Based Learning (PjBL) Approach	95	90	92,5	Very Practical
2	Time effectiveness	95	95	95,0	Very Practical
3	Interpretation	90	95	92,5	Practical
4	Equivalence	80	90	85,0	Very Practical
	Rata-rata	**90,0**	**92,25**	**91,25**	**Very Practical**
Information: D1 = Lecturer 1 D2 = Lecturer 2					

To assess the practicality of Interactive Video Tutorials with a Project-Based Learning (PjBL) Approach, input from students is needed. This data was obtained after the learning took place through a questionnaire given to students. The results can be seen in Table 3 below:

Table 3. Description of the Results of Data Analysis on Student Practicality

Number	Assessment Aspects	Assessment Presentation	Category
1	Ease of use of Interactive Video Tutorials with Project-Based Learning (PjBL) Approach	96,6	Very Practical
2	Display and power of Interactive Video Tutorials with Project-Based Learning (PjBL) Approach	96,2	Very Practical
3	Time Efficiency	97,3	Very Practical
	Average	**96,7**	**Very Practical**

4 Conclusion

This research aims to develop an Interactive Video Tutorial with a Project-Based Learning (PjBL) approach for the CAD-Assisted Mechanical Drawing course at the Faculty of Engineering, Universitas Negeri Medan, and to evaluate its validity and practicality. The results of the study indicate that the developed video tutorial is valid, with an average validation score of 0.95. Expert evaluations show that all components of the video are deemed valid, requiring only minor revisions. These revisions were made based on expert suggestions to produce Prototype II, which was subsequently tested.

The practicality of the video tutorial was also found to be high, with positive responses from lecturers at 91.25% and from students at 96.7%. Observations indicated that the video tutorial was well-received by users, being considered very practical in terms of ease of use, time efficiency, and presentation. Trial data demonstrated that the video tutorial is effective in enhancing students' understanding of modeling material, with an average student learning outcome score of 85.94 and a class completion rate of 94.59%.

The main findings of this research are that the use of the PjBL-based Interactive Video Tutorial successfully addresses the issue of delayed assignment submissions and improves students' abilities to interpret drawings. The video tutorial provides clear guidance and an organized structure in the learning process, which in turn increases students' motivation and understanding of mechanical drawing material.

The results of this study suggest that the Interactive Video Tutorial can serve as an effective learning tool for other courses and can be a reference for other technical education institutions in developing technology-based learning methods. Thus, the PjBL-based Interactive Video Tutorial is an innovative solution that can enhance the quality of learning in the CAD-Assisted Mechanical Drawing course and can be adapted for broader use in the context of technical education.

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