Feasibility Test of Augmented Reality (AR) in Technical Drawing Learning of Manufacturing at SMK N 1 Rembang

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ABSTRACT

The purpose of this study is to analyze the feasibility of interactive e-jobsheet based on Augmented Reality in learning Manufacturing Engineering Drawing at SMK Negeri 1 Rembang, Machining Engineering expertise competency. This study uses a quantitative method with an experimental approach of the true experimental design type. The research design used is Pretest-Posttest Control Group Design, where there are two groups, namely the experimental group that received treatment in the form of learning using AR-based e-Jobsheet with the Problem Based Learning PBL model, and the control group that used conventional learning methods. Based on the results of the research and discussion, it can be concluded that an interactive e-jobsheet based on Augmented Reality has been successfully developed which is designed with reference to the independent curriculum, especially in the preparation of simple drawings. The developed product obtained a very good level of feasibility based on the validation results from various parties, namely material experts from lecturers of Mechanical Engineering Education UNY by 90% with a very feasible category, SEAMOLEC media experts by 98% with a very feasible category, and the response of teachers of SMK Negeri 1 Rembang by 84% which is also included in the very feasible category. Likewise, the results of student responses reached 86%.

Keywords— E-Jobsheet, Augmented Reality, Manufacturing Engineering Drawings, Control, Experimentation

INTRODUCTION

Education is essentially an effort to cultivate humanity. Education is very strategic in enlightening the life of a nation and is necessary to improve the overall quality of the nation [1]. All societies around the world have an obligation to provide education. Education will have an impact on the progress of a nation's development and on the quality and broad-mindedness of its human resources. A country can be said to be advanced if its education system is also of high quality.

Education is the most important aspect of a nation's progress. The progress of a nation can be seen from the progress of its education system [2]. Quality education is the main foundation for creating a generation that is competent, innovative, and ready to face global challenges. An advanced education system not only focuses on improving students' cognitive aspects but also integrates technology and learning methods that are relevant to the needs of the times. Therefore, good quality education plays an important role in building the nation's competitiveness at the global level.

Vocational education aims to equip students with skills/expertise in specific fields so that they are ready to enter the workforce as productive workers or develop themselves to create job opportunities for themselves and others [3]. Vocational education is part of the national education system that prepares individuals to be more capable of working in a particular job group or field [4]. This education not only focuses on improving technical skills, but also encourages students to become productive workers who are able to compete in the job market. In addition, vocational education provides opportunities for students to develop themselves as entrepreneurs, creating jobs for themselves and others. Thus, vocational education plays an important role in supporting economic growth and reducing unemployment rates [5].

Table I Indonesia's Open Unemployment Rate

Level of Education	Open Unemployment Rate Based on Education Level		
	2021	2022	2023
No/Never Attended School/Did Not Complete & Completed Elementary School	3,61	3,59	2,56
Junior High School	6,45	5,95	4,78
General Senior High School	9,09	8,57	8,15
Vocational Senior High School	11,13	9,42	9,31
Diploma I/II/III	5,87	4,59	4,79
University	5,98	4,80	5,18

The open unemployment rate for vocational high school (SMK) graduates is 9.31%, which is still the highest compared to graduates from other levels of education [6]. Although SMK are designed to produce workers who are ready to enter the industrial world and the job market, the high unemployment rate among SMK graduates indicates a mismatch between the skills taught in school and the needs of industry. This phenomenon reflects major challenges in the vocational education system in Indonesia, including the relevance of the curriculum, limited access to internships, and support for job placement. This high unemployment rate requires serious attention from the government, schools, and industry to design more effective collaborative strategies to bridge the gap between education and employment.

Currently, the largest number of vocational schools are in the field of Technology and Engineering, reaching 48.15% [7]. This shows that this sector has great potential in developing competent human resources. However, to maximize this potential, more attention is needed from the government, educational institutions, and the community. Thus, vocational schools can improve the quality of education and prepare the younger generation to face the challenges of ever-evolving technology. Therefore, more intensive efforts are needed to support and improve the performance of vocational schools in the field of Technology and Engineering.

Based on data from the National Labor Force Survey released by the Central Statistics Agency (BPS) in 2019 and processed by the Center for Educational and Cultural Policy Research in 2020, the number of unemployed vocational school graduates with selected skills shows that the field of Mechanical Engineering ranks third with 221,368 unemployed people.

Learning 21st century has shifted and of abandoned traditional learning that is oriented and centered on educators [8]. Technology-enhanced education has played a pivotal role in student learning and development [9]. Effective learning occurs when students and teachers interact reciprocally while using various types of teaching concepts and learning resources such as learning media [10]. Students need to be prepared to have skills in manufacturing engineering design, so special teaching and training are required. Machining Engineering skills competency, where this material applies the use of Computer Aided Design (CAD) in the learning process. CAD knowledge will be useful and can lead students to be ready to enter the world of work [11], [12].

The application of Manufacturing Engineering Drawing is one of the important subjects in the curriculum of the Machining Engineering Department at Vocational High Schools (SMK) [13]. However, students often face difficulties in understanding 2 dimensional drawings. Conventional learning methods that are still widely used, such as lectures and textbooks, are ineffective in explaining the understanding of these 2 dimensional drawings. As a result, students' critical thinking skills in understanding and applying Manufacturing Engineering Drawing are low.

With regard to technological developments in the world of education, the role of learning media has become

increasingly important [14]. Media not only functions as a supporting tool, but also as a tool that can improve the effectiveness and efficiency of the teaching and learning process. The appropriate use of media can help simplify the delivery of material, clarify abstract concepts, and increase student participation. Therefore, the use of innovative technology and learning media is key to creating a more interactive and enjoyable learning experience.

Based on observations and interviews at SMK Negeri 1 Rembang, it was found that many students had difficulty learning manufacturing engineering drawings. Students often cannot visualize 3-dimensional objects, making it difficult for them to draw in 3 dimensions. This has an impact on their low motivation to learn in solving problems related to manufacturing engineering drawings. Therefore, innovation in learning media is needed to improve students' understanding and motivation.

In this modern world, Augmented Reality (AR) has become more and more prominent [15]. Augmented Reality (AR) technology is a technology that combines virtual information with the real world [16]. The application of Augmented Reality (AR)-based learning media is expected to be a solution to overcome this problem. Augmented Reality (AR) has the ability to display virtual objects in a real environment, thereby helping students better understand 2-dimensional images through interactive and realistic visualizations [17]. In the practice of learning the use of augmented reality, technology is still not widely used [18].

Basically, problem-solving ability is a fundamental ability and must exist in the nation's generation [19]. Problem based learning is an approach oriented towards a constructivist cognitive view that includes contextual, collaborative, metacognitive thinking characteristics and facilitates problem solving [20]. Problem-Based Learning (PBL) also facilitates the development of higher-order thinking skills, such as analysis, evaluation, and synthesis of information. Students can connect theory with real-world practice, making the material they learn more meaningful and contextual. In addition, PBL encourages students to learn independently and take responsibility for their learning process, which ultimately increases motivation and confidence. In the context of a modern workplace that is increasingly complex and dynamic, the ability to think critically, collaborate, and solve problems is a valuable asset. This makes PBL a highly relevant method for education in a modern era full of change and complexity.

METHOD

This study used a quantitative method with a true experimental design approach. The research design used is a Pre-test-Post-test Control Group Design, in which there are two groups, namely the experimental group that received treatment in the form of learning using AR-based E-Jobsheets with the PBL model, and the control group that used conventional learning methods. Through this design, comparisons of student motivation and learning outcomes can be measured more accurately both before and after treatment.

The variables in this study consist of independent and dependent variables. The independent variable is the use of Augmented Reality (AR)-based learning media, while the dependent variables include student learning motivation and learning outcomes in Manufacturing Engineering Drawing learning. The relationship between these variables is the basis for analyzing the effectiveness of using innovative learning media in improving the quality of the learning process.

The eligibility category is used as a basis for determining the eligibility results of the e-jobsheet. These results then show the eligibility level of the e-jobsheet based on each aspect. A product can be said to be eligible or highly eligible if it receives an average score of ≥ 61% and ≥ 81% in the eligibility assessment.

RESULT AND DISCUSSION

Result

Validation of Subject Matter Experts in Mechanical Engineering Education at UNY

Subject matter experts assess the suitability of interactive e-jobsheets in relation to the material being taught.

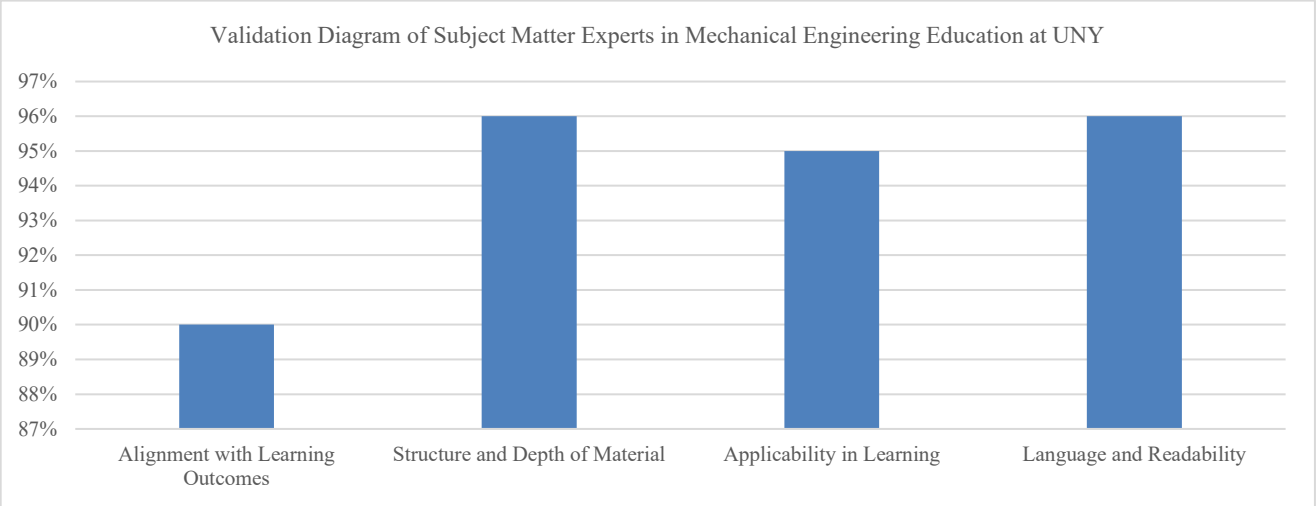
Teachers and lecturers assess the suitability of e-jobsheets in relation to the material being taught.

TABLE II Validation of Subject Matter Experts in Mechanical Engineering Education at UNY

No	Aspect	Score	Max.Score	Percentage (%)
1	Alignment with Learning Outcomes	27	30	90%
2	Structure and Depth of Material	24	25	96%
3	Applicability in Learning	19	20	95%
4	Language and Readability	24	25	96%
Total		**94**	**100**	**94%**

From the material assessment by Mechanical Engineering Education Lecturers, an average suitability percentage of 94% was obtained, which falls into the "Highly Suitable" category. The following is a presentation of the material assessment data in diagram form:

Fig. 1. Validation Diagram of Subject Matter Experts in Mechanical Engineering Education at UNY



Expert Validation of Teaching Materials at SMK N 1 Rembang

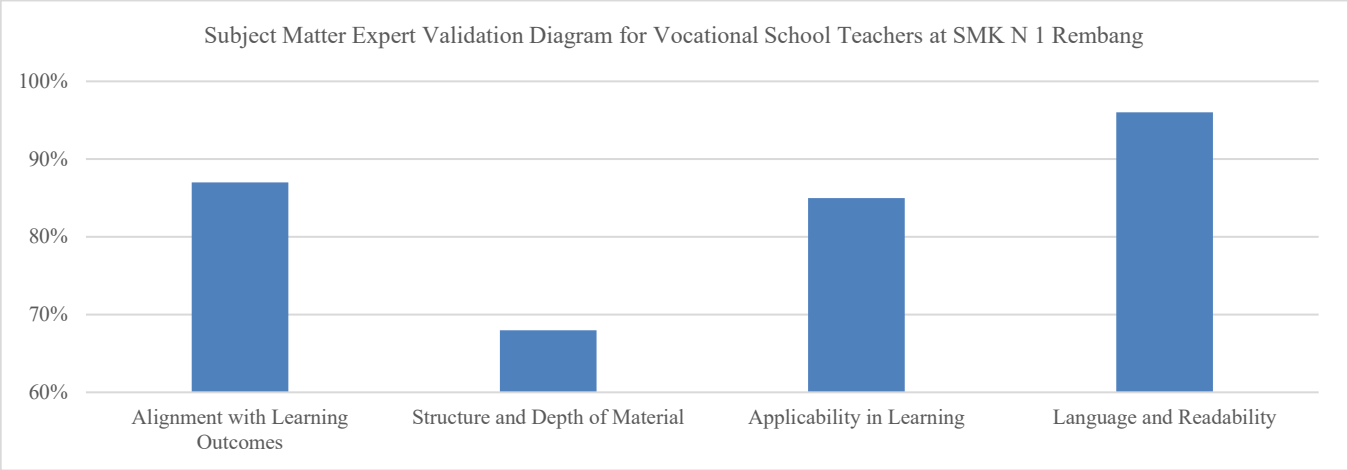
Subject matter experts assess the suitability of interactive e-jobsheets in relation to the material being taught. Teachers and lecturers assess the suitability of e-jobsheets in relation to the material being taught.

TABLE III Validation of Subject matter experts at smk n 1 rembang

No	Aspect	Score	Max. Score	Percentage (%)
1	Alignment with Learning Outcomes	26	30	87%
2	Structure and Depth of Material	17	25	68%
3	Applicability in Learning	17	20	85%
4	Language and Readability	24	25	96%
Jumlah		**84**	**100**	**84%**

From the material assessment by teachers at SMK Negeri 1 Rembang, an average suitability percentage of 84% was obtained, which falls into the "highly suitable" category. The following is a presentation of the material assessment data in diagram form:

Fig. 2. Subject Matter Expert Validation Diagram for Vocational School Teachers at SMK N 1 Rembang



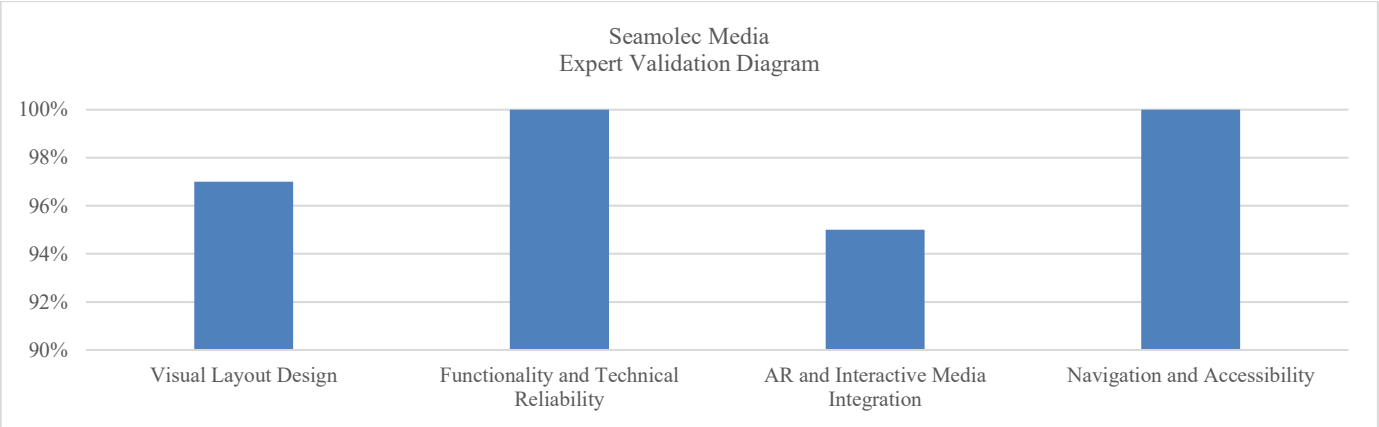
Seamolec Media Expert Validation Media experts assess the suitability of interactive E-jobsheets from a media/visual perspective.

TABLE IV Seamolec Media Expert Validation

No	Aspect	Score	Max. Score	Percentage (%)
1	Visual Layout Design	34	35	97%
2	Functionality and Technical Reliability	25	25	100%
3	AR and Interactive Media Integration	19	20	95%
4	Navigation and Accessibility	20	20	100%
Total		**98**	**100**	**98%**

From the material assessment by Seamolec media experts, an average suitability percentage of 98% was obtained, which falls into the “highly suitable” category. The following is a presentation of the material assessment data in diagram form:

Fig. 2. Seamolec Media Expert Validation Diagram



Student Response

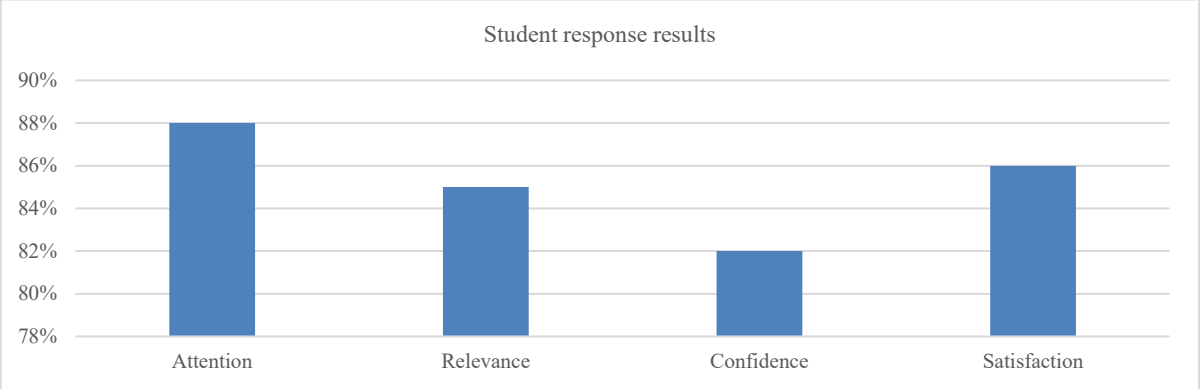
Student responses were intended to determine the suitability of the e-jobsheet developed for real/actual classes. These user responses were collected to find out students' opinions after using the e-jobsheet. Students assessed aspects such as attention, relevance, confidence, and satisfaction.

TABLE V Student Response

No	Aspect	Score	Max. Score	Percentage (%)
1	Attention	491	560	88%
2	Relevance	475	560	85%
3	Confidence	459	560	82%
4	Satisfaction	489	560	86%
Total		**1914**	**2240**	**86%**

Based on the assessment of students in the Experiment class regarding the interactive e-jobsheet, this jobsheet received excellent scores in all aspects, with a percentage of 88% for attention, 85% for relevance, 82% for confidence, and 86% for satisfaction. Overall, this motivation received a total percentage of 86%. Based on the qualifications, this score falls into the "Highly Meritorious" category. This shows that the interactive e-worksheet has met very good standards in terms of attention, relevance, confidence, and satisfaction, making it very suitable for use as a learning tool. The following is a presentation of the data from the students' responses in the form of a diagram:

Fig. 3. Diagram of Student Questionnaire Results



DISCUSSION

Based on the validation conducted by subject matter experts from the Mechanical Engineering Education Department at UNY, the interactive e-jobsheet for Manufacturing Engineering Drawing received an average feasibility rating of 98%, which falls into the "highly feasible" category. From these results, the linguistic aspect received the highest score with a percentage of 84%, indicating that the language used in the e-jobsheet is clear and easy to understand. However, the graphic aspect received the lowest score, namely 60%, which indicates that improvements are needed in terms of visual appearance to make it more attractive and easier to understand.

Based on the results of subject matter expert validation from SEAMOLEC at SMK Negeri 1 Rembang, the interactive e-jobsheet for Manufacturing Engineering Drawing received an average score of 98%, which falls into the "highly feasible" category. This shows that the e-jobsheet has met the eligibility criteria in terms of Visual Design and Layout, Functionality and Technical Reliability, AR Integration, and Interactive Media. This e-jobsheet can be effectively implemented at SMK Negeri 1 Rembang, but some refinements are needed to optimize its support for learning.

Meanwhile, the validation results from subject teachers at SMK Negeri 1 Rembang show that this e-jobsheet received an average score of 8%, which falls into the "highly feasible" category. This assessment shows that the e-jobsheet has met the overall feasibility criteria very well, especially in terms of language and readability, which received the highest score of 95%. This e-jobsheet is highly effective for use at SMK N 1 Rembang, as it has provided excellent support for the technical manufacturing drawing learning process.

Based on the validation results by two validators, namely PTM UNY Lecturers and SMK Negeri 1 Rembang Teachers, the evaluated material received an eligibility rating of 89% with a "Very Eligible" criterion. The validator from the UNY Mechanical Engineering Education Lecturer gave a rating of 94%, which falls into the "Very Feasible" category. Meanwhile, the teacher from SMK Negeri 1 Rembang gave a higher rating of 84%, which falls into the "Very Feasible" criteria. Overall, the learning media tested has met high feasibility standards and can be used to support learning activities at school. The validation by subject matter experts aligns with the research by Fitkirana & Kurniawan and Hidayat, where the results of subject matter expert validation showed "highly suitable" and "highly suitable" [21], [13].

Meanwhile, validation from media experts shows that this e-jobsheet is highly suitable for use, with an average score of 98%. Functionality and reliability received a perfect score of 100%, indicating that this jobsheet has been designed with good functionality and reliability and provides functions that meet user needs. However, the AR and interactive media integration aspects received a score of 80%, indicating that there is still room for improvement in AR and interactive media integration. This validation from media experts is in line with the research by Fitkirana & Kurniawan and Hidayat, with the results of media expert validation showing "highly feasible" [21], [13]. Overall, the results from both experts indicate that this e-jobsheet is highly feasible for use.

Based on the results of the student response questionnaire regarding the use of e-jobsheets, a total score of 1,914 out of a maximum score of 2,240 was obtained, reaching a percentage of 86%. When viewed from each aspect, the attention indicator obtained the highest percentage of 88%, which shows that the module was able to attract the interest and focus of students in the learning process. The relevance aspect received a percentage of 85%, indicating that the module content was considered relevant to learning needs and easy to relate to the students' existing experiences and knowledge. Furthermore, the confidence aspect received a percentage of 82%, meaning that the module can help increase students' confidence in understanding the material and completing the assigned tasks. Meanwhile, the satisfaction aspect received a percentage of 86%, indicating that students were satisfied with the appearance, content, and ease of use of the module. Overall, these results indicate that the developed module is very suitable for use as teaching material because it is able to provide an interesting, relevant, motivating, and satisfying learning experience for students.

Overall, this interactive e-jobsheet has proven to be feasible for implementation at the vocational school. At SMK Negeri 1 Rembang, the e-jobsheet is considered very feasible. This is in line with the research results of Fitkirana & Kurniawan, Hidayat, and Romadin [21], [13], [22]. The quality of the e-jobsheet, which supports interactive learning and is in line with learning material requirements, makes this e-jobsheet capable of improving student learning outcomes at vocational schools, although further adjustments are needed in certain aspects.

CONCLUSIONS

Based on the results of research and discussion, it can be concluded that an interactive Augmented Reality e-jobsheet has been successfully developed, designed with reference to the independent curriculum, particularly in the preparation of simple images. The developed product obtained an excellent level of feasibility based on the validation results from various parties, namely 90% from subject matter experts in the highly feasible category, 98% from media experts in the highly feasible category, and 84% from teaching staff responses, which also fell into the highly feasible category. Similarly, the results from student responses reached 86%.

Thus, it can be confirmed that the use of interactive e-jobsheets based on Augmented Reality is proven to be effective in improving student learning outcomes, especially in the subjects tested at vocational schools. This finding also shows that the integration of Augmented Reality technology in jobsheets can be one of the learning innovations that supports the achievement of the independent curriculum objectives.

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