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Multimedia Engineering Drawing Animations to Improve Vocational High School Students' Technical Drawing Concepts

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ABSTRACT

The research aims to develop innovative multimedia animation engineering drawing (MMAED) in technology and engineering in Vocational High Schools. The research method used is research and development, which broadly covers the manufacturing and testing stages. The study population was vocational students in technology and engineering expertise. Learning is done in two classes: Class A as a control class and class B as an experimental class. Data collection tools in the form of tests, rubrics, and questionnaires. Data were analyzed by descriptive analysis, percentage, and N-gain. The results of this study are Multimedia Animation Engineering Drawing (MMAED) with unique characteristics that are accessible or affordable to the eyes and logic of students, by orthogonal projection material that requires imagination or imagination of the appearance of an object. The mastery of the concept of orthogonal projection material has increased after using MMAED so that it reaches a high category.

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1. INTRODUCTION

Education in Indonesia is divided into primary and secondary education and higher education. One of the secondary education in Indonesia is a vocational high school (SMK). SMK is a form of formal education unit that organizes vocational education at the secondary education level as a continuation of Junior High School (SMP/MTS) or other forms of equivalent or continuation of learning outcomes that are recognized as equal/equivalent to SMP/MTS. SMK has many skill programs. One of the vocational skills programs is mechanical drawing engineering.

Education is the right of every human being. Education is a conscious and planned effort to create an atmosphere and learning process so that students can actively develop their potential to have good personality strengths, religious spirituality, self-control, intelligence, morality, and skills needed by themselves and the community (UU Sisdiknas no. 20 of 2003). Education, in essence, is a conscious process to develop individual potential so that they have intellectual, emotional, character, and skills to be ready to live in a society (Widisila et al., 2014).

The vocational expertise program in the form of mechanical drawing is expected to be one of the solutions to prepare Indonesian people to have the ability to be productive, creative, and innovative so that they can contribute to the progress of Indonesia. One way to achieve these expectations, among others, is by developing a balance between the development of spiritual and social attitudes, curiosity, creativity, and cooperation with intellectual and motor skills. This follows the new paradigm of developing the 2013 SMK curriculum (Http:/www.ditpsmk.net/post/news.html).

Implementing the 2013 curriculum as a substitute for the education unit level curriculum (KTSP) in primary and secondary education impacts a paradigm shift in the education system. The development of the SMK curriculum is aimed at dealing with internal and external challenges. Internal challenges related to the condition of education are associated with educational demands that refer to 8 (eight) national education standards, which include content standards, process standards, graduate competency standards, educators and education personnel standards, facilities and infrastructure standards, management standards, financing standards, and educational assessment standards. Meanwhile, external challenges are related to the current globalization and various issues related to environmental problems, advances in information technology, the rise of creative and cultural industries, and the development of education at the international level. In addition, external challenges are also related to the shift in world economic power, the influence and impact of technology as well as the quality, investment, and transformation of the education sector, so vocational education has an essential role in preparing a generation that has skills in their field competencies so that they can compete during the current competition (Muljono, 2006; Widiaty, 2017).

Preparing teachers to provide skills can be done in one way, namely the use of teaching materials. Teaching materials are also expected to answer internal and external challenges. In addition, the use of teaching materials is one of the implementations of the 2013 curriculum to help fulfill adequate facilities, infrastructure, learning resources, and resources. The availability of learning media is still limited, while the 2013 curriculum demands standard facilities and infrastructure and optimal graduate competency standards (Hakim et al., 2014).

The problem faced in learning drawing competency standards in the mechanical drawing engineering department is the lack of teaching materials, so the achievement of learning objectives is not optimal. This is in line with Soma, Candiasa, & Tegeh's (2014) research which states that the learning objectives have not been achieved as expected due to the lack of teaching materials. Meanwhile, according to the research results of Kartika, Santyasa, & Warpala (2014), the application of learning models that are not appropriate and the scope of material that is not by the syllabus can result in low student achievement. The learning model carried out by teaching teachers, especially vocational teachers, is still classified as not innovative and more dominant than *teacher-centered*. Computer/laptop facilities owned by students have not been fully optimized to support the learning process (Kartika et al., 2014). Some things experienced by teachers in vocational training in the learning process are lack of mastery of technology-based learning media. Therefore, it is necessary if vocational teachers are given reinforcement in the use of technology-based media in the implementation of learning (Hidayat, 2020; Tridiana & Rizal, 2020)

In a modern economic and socio-cultural situation, the quality of education is a strategic factor in innovative developments in Russia (Makarov et al. in Torkunova, 2014). Educational innovation in higher vocational schools is significant in answering the challenges of modernization and development based on the needs of modern realities (Torkunova, 2014). In contrast to the curriculum in Turkey, secondary schools use a learning style consisting of visual, auditory, and kinesthetic. The active role of students is essential in implementing this curriculum.

In several mechanical drawing engineering vocational schools met by researchers, the teaching system is generally still conventional. This means that the learning process is still teacher-centered, so if the teacher does not enter to carry out learning, the students only do the assigned tasks. Teachers who still have much time to explain the tasks given will be discussed at the next meeting. However, from observations made by researchers, many teachers did not discuss the assignments given, so many students complained that they did not understand the assigned material. Therefore, teaching media is needed in the form of innovative teaching materials to facilitate the achievement of learning objectives.

Two essential elements in the learning process are learning methods and media (Azhar, 2008 Budiman, 2012). Several reasons indicate that learning media can improve the quality of the learning process. Each media has a unique ability to explain educational material, and the effect of using media will provide a different understanding for each student (Budiman, 2012). Animated multimedia can also significantly impact good learning (Tien et al., 2018). Interactive animated multimedia can also increase mastery of concepts and skills (Wiana, 2018).

Teachers also play an essential role in achieving learning objectives and teaching materials. These roles include tutors, coaches, instructors, and teachers who must encourage students to increase knowledge through experience. To become a good teacher, facilities are needed to make the teaching and learning process more manageable. Teachers must develop students' interest to have the willingness to explore all the knowledge they want to know in the best way (Ahmad et al., 2013). One of the best ways is to take advantage of information and communication technology (ICT) development. Firdania's research (2016) stated that the *Computer Assisted Instruction* (CAI) application proved worthy of being a learning medium. Meanwhile, the results of research by Situmorang, Sitorus, & Situmorang (2015) stated that the development of multimedia-based innovative and interactive high school/MA chemistry teaching materials helps students achieve competence and improve learning outcomes. In line with the results of Agusta's research (2015), the bilingual website "Close to Radioactivity" learning media developed is feasible to be used as an independent learning resource for high school/MA students and can improve student learning outcomes.

The results of research by Baukal, Charles, Ausburn, & Lynna (2016) show that workers who continue their education state that they like animated multimedia in delivering material or learning. The results of research support this by Rhodes (2013) that in America, students who study science, technology, engineering, and mathematics stated that the use of animated multimedia and narration dramatically benefits students in learning compared to the use of static multimedia images and text. The research results by García-Rodicio & Héctor (2014) showed that 97 undergraduate students learning about plate tectonics using animated multimedia triggered students to think critically so that students asked many questions about the material delivered through animated multimedia. Animated multimedia offers new insights into learning machine learning analytical techniques about student learning trajectories in the learning environment so that students have more complex and open thinking (Blikstein & Worsley, 2016). Research results support this by Katsioloudis, Dickerson, Jovanovic, & Jones (2015) that multimedia animation in learning and teaching results in more significant differences in spatial visualization abilities in mechanical engineering students.

Chiou, Tien, & Lee's (2015) research state that animated multimedia teaching materials improve learning achievement, retention, and better learning satisfaction. While the results of other studies conducted on electrical employees, training methods based on multimedia animation technology and equipped with computer software and database technology increase the learning efficiency of electrical employees and significantly reduce training costs (Liao et al., 2012). In addition, the results of research by Fratandha, Suherman, & Komaro (2015), show that the use of multimedia animation can improve critical thinking skills in learning metal reinforcement materials in engineering materials courses. Hadibin, Purnama, & Kristianto (2012) show that computer network engineering learning media applications make the delivery of lessons more varied so that students understand the material more quickly and are interesting, not boring. The application of interactive multimedia by teachers during the learning process can also improve student learning outcomes (Anas, 2019). Other research on interactive media can also increase learning achievement and motivation (Bustanil & Ardianto, 2019).

An in-depth study of the implementation of productive program learning in the context of implementing the SMK curriculum is needed to improve the process of implementing learning to obtain the expected results. Teaching materials to achieve the expected competencies according to Graduate Competency Standards (SKL) are necessary so that students have competencies that follow SKL and according to the Business/Industry World demands. This research is focused on developing innovative technical drawing teaching materials for mechanical drawing engineering competencies in Vocational High Schools. Develop innovative multimedia-based teaching materials using Adobe Flash software Illustrator so that the innovative teaching materials of the technical drawing will become more attractive to students. Students can learn independently, while teachers can make their work easier. This research aims to develop innovative multimedia animated technical drawing (MMAGT) teaching materials in technology and engineering at Vocational High Schools. The results of this study are expected to contribute to the development of innovative technical drawing teaching materials for the field of technology and engineering expertise in Vocational High Schools. Thus, the results of this study will enrich the theoretical repertoire of value cultivation informal educational institutions.

2. METHODS

2.1. Design research

The method used in this research is to use research and development methods (research and development, or R & D). Borg & Gall (1983) define R & D in education as "a process used to develop and validate educational products," namely the processes used to create, develop and validate educational products.

The product that will be developed in this research is innovative teaching materials for technical drawing for Vocational High School (SMK) students, technology and engineering expertise, and a mechanical engineering expertise program. The R & D method in this research is to create, develop, and implement innovative teaching materials for vocational students in mechanical engineering and automotive engineering.

A chart can express the research steps for developing innovative teaching materials in engineering drawing subjects. By adapting Komaro (2015) chart, the research and development steps are shown in Figure 1.

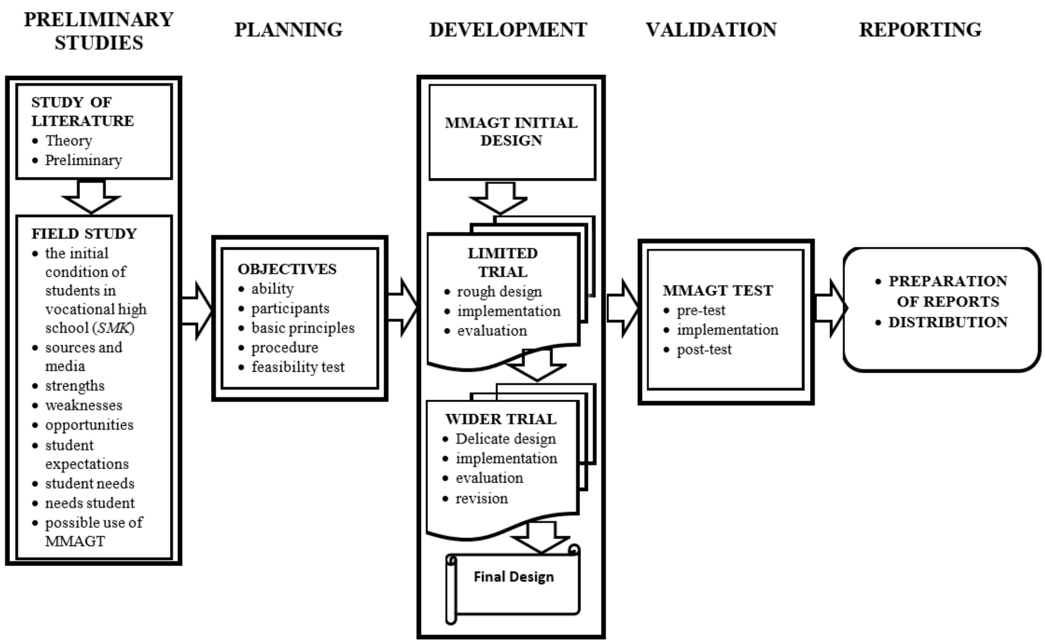

Figure 1. Steps of the R & D Model

2.2. Participants

Many participants have been involved in the research and development of innovative multimedia-based animation teaching materials (MMAGT) in technical drawing subjects. The participants consisted of the subject or main participants: vocational high school students in technology and engineering expertise, mechanical engineering, and automotive engineering expertise programs. There were 50 students involved.

Other participants involved include teachers in vocational high schools who teach technical drawing subjects as sources of information and participants during the preliminary study. Other participants are educational experts or experts (both vocational education experts or education experts working in the manufacture of teaching materials or learning media, especially SMK) and practitioners in Information Technology, especially practitioners working in programming and animation. Expert validation was carried out on 2 experts in animation and teaching materials at Vocational High School (*SMK*).

2.3. Research

Instruments The research instruments to be made consist of: tests, rubrics, and questionnaires (Komaro, 2015). The explanation of each instrument is as follows.

2.3.1. Tests

The tests in this study include tests of mastery of concepts and problem-solving skills. The concept mastery test was developed based on the concept mastery indicator, and the problem-solving skill test was developed based on the problem-solving indicator. The tests developed on the scope of the concept of orthogonal projection, American projection (third angle), and European projection (first angle).

Between indicators and tests, items need to be assessed for conformity with validation. The validation includes content validity (the suitability of the test with the material or content of technical drawing lessons for SMK students), construction validity (the suitability of test items to measure aspects of thinking according to indicators), and advance validity (assessment of test performance). Content validity, especially in terms of the assessment criteria from the concept side, includes test items within the scope of the defined concept and the truth of the concept. Construction validity includes an assessment of the suitability of test items with indicators of problem-solving skills containing wasted words and distracting relevance. The expert appraisers for this validation came from technical drawing education experts and education research and evaluation experts.

2.3.2. Rubric

To score the quality of a product, a Rubric is needed. According to Johnson & Johnson Maurer in Widodo (2010), the rubric is the scoring criterion of a performance or product. This study uses rubrics to assist expert assessors in assessing the quality of innovative teaching materials (MMAGT) and product assessment of problem-solving skills.

2.3.3. Questionnaire

The embodiment of the questionnaire in this study was in the form of a questionnaire, which was used to obtain data from respondents. The data is converted into data that can be used to measure what people know, like/dislike, and what people think (Tuckman in Widodo (2010). The questionnaire instrument in this study consisted of 1) student responses to technical drawing learning (for preliminary studies); 2) Concept mastery test; 3) Student responses to MMAGT, and 4) Students' responses to the learning of the developed teaching materials.

To facilitate this research, two assumptions were made. The first assumption is that humans, in this case, SMK students, are active participants in their cognition actions. This is based on the opinion that cognition is a mental process involved in gaining knowledge and understanding, including thinking, knowing, remembering, judging, and solving problems. According to Kuswana (2011), cognition is a higher level of brain function and includes language, imagination, perception, and planning. Students as students in SMK are assumed to follow cognitive theory in their learning. With this assumption, SMK students do things to learn technical drawing through innovative teaching materials (MMAGT) are readily accepted as meaningful cognitive actions, thus avoiding meaningless physical actions. The assumptions are taken to ensure that the learning of technical drawings affects student learning outcomes that reflect the increasing competence of students.

The second assumption is that internal and external factors influence the learning process and outcomes. Following Slameto (2010) opinion, external and internal factors affect learning outcomes. Where internal factors exist in the individual who is learning, while external factors exist outside the individual, with different internal and external factors, students may produce different learning outcomes.

Based on these assumptions, a chart was compiled by adapting Komaro (2015) chart, as shown in figure 2. The picture shows three aspects that determine vocational students' objectives and style of learning technical drawing. Increased competence is shown by increasing student learning outcomes. These three aspects are the diversity of vocational students' abilities, the need for job opportunities, and the nature and function of learning technical drawing.

The three aspects above are used to obtain technical drawing learning objectives for vocational students, namely; mastery of technical drawing concepts and technical drawing reading skills.

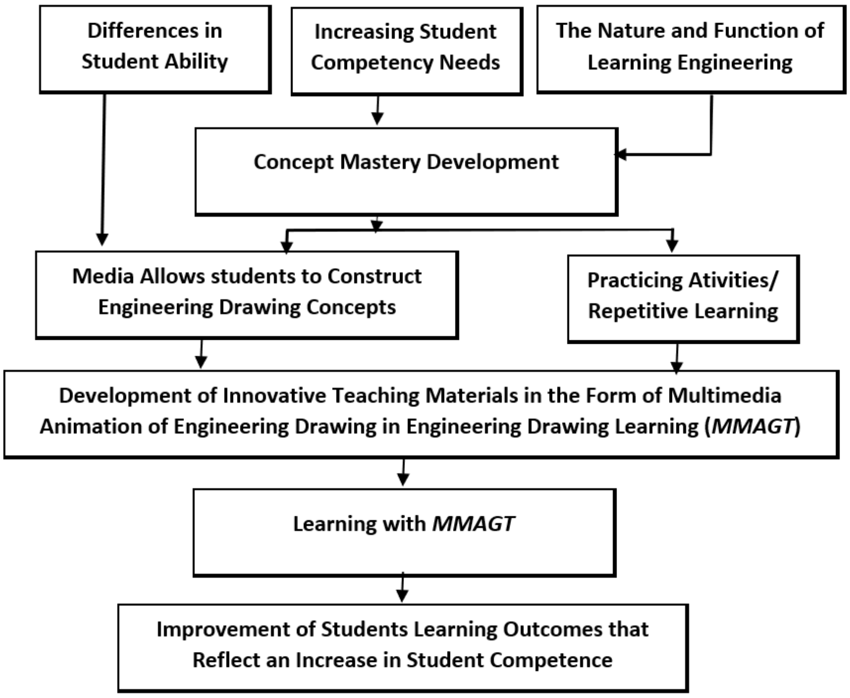

Figure 2. Research paradigm chart

In this research paradigm, it is stated that to achieve the objectives, it is necessary to do learning that uses MMAGT to construct engineering drawing concepts for vocational students as a basis for applying concepts and reading technical drawings. Learning using innovative teaching materials (MMAGT*)* can be done "anything" and "anywhere." Students can reflect by looking back at these innovative teaching materials.

2.4. Research Procedures

Research procedures are concrete and detailed steps, which are the elaboration of the development model. The development procedure for research and development of innovative teaching materials for learning engineering drawings is carried out through stages. The first stage needs analysis in observation, interviews, and distribution questionnaires. Second, designing innovative teaching materials (MMAGT) in the form of analyzing similar teaching materials, making *storyboards*, making *flowchart views*, and collecting materials. Third, product validation includes material expert validation. Fourth, field trials include one-on-one, small group, and large group trials. According to Soenarto in Komaro (2015), in the procedure, the researcher mentions the properties of the components at each stage in product development and explains the relationship between components in the system. The procedure consists of a 10-step development procedure, according to Borg & Gall (1983), with a more apparent number of respondents.

The research development procedure, according to Borg and Gall, can be further simplified into 5 main steps as described by Soenarto (2005), including: Performing product analysis to be developed; Developing initial products; Expert validation and revision; Small-scale field trials and product revisions; Large-scale field trials and final products.

2.5. Data Analysis

Data analysis techniques in this study generally include descriptive analysis. Descriptive analysis was conducted to describe data from questionnaires, observations, and rubrics carried out qualitatively in the form of descriptions of information based on specific categories and in the quantitative form in the form of percentages and the average of data on improving learning outcomes (*N-gain*). A summary of the research questions, the data generated, and the method of data analysis are presented in table 1.

Table 1. Summary of research questions, data generated, and methods of data analysis

Aspects measured	Data	Method of Data Analysis
Student responses to learning Engineering Drawing (for preliminary study	Product Assessment Score (Questionnaire)	Descriptive, percentage
of student responses using multimedia animation technical drawings (Initial	score Product (Questionnaire)	Descriptive, percentage
Assessment of technical drawing animation multimedia (MMAGT) by Experts	Assessment Score (Rubik)	Descriptive, percentage
Effectiveness of applying technical drawing multimedia animation (MMAGT) to improve mastery of technical drawing concepts in SMK students	ScoreTest Mastery of Concepts Drawing technique	N-*gain* (Hake, 1999) between the experimental and control groups.
Student responses to the learning of Engineering Drawing with the multimedia learning model of animated technical drawing (MMAGT).	Rating Score (Questionnaire)	Descriptive, percentage

The validity test in this study was a *nonequivalent control group design.* In this research design, there are two groups: an experimental group and a control group. Both groups were given a *pre-test* to determine whether there was a difference between the experimental and control groups in the initial state.

The two-mean difference test of two samples was carried out to determine whether, between the experimental group and the control group, there was a difference *in N-Gain* (normalized gain) according to Hake (1999), namely:

$$\text{(N-Gain)} = \frac{\%\, actual\ gain}{\%\, potencial\ gain} = \frac{\%\, skor\ postes - \%\, skor\ pretes}{100 - \%\, skor\ pretes} \quad (1)$$

In this study, analysis was also carried out descriptive N-Gain using N-Gain criteria (Hake, 1999), namely: 1) Increase with "high-gain" if (*N-Gain*) > 0.7; 2) Increase with "medium-gain" if 0.7≥*N-Gain* 0.3, and 3) Increase with "low-gain" if (*N-Gain*) < 0.3. At the same time, another criteria for descriptive analysis is the eligibility criteria, which is 75% of the ideal score.

3. FINDINGS AND DISCUSSION

A limited trial was conducted in a mechanical engineering class of 29 students. Data from the limited trial results are as in table 2.

Table 2. The results of the *-Gain* on the limited trial

Data	**Highest**	
Pre-Test	Lowest	63
	Lowest	14
	Average	34.80
Post-Test	Highest	88
	67.27	40
	Average	N-
N-gain (%)	Highest	82.35
	Lowest	12.5
	Average	51.00

From the limited trial, it can be seen that the average N-gain is 51.00 on a scale of 100 or 0.51. This value shows that this media can improve students' abilities but only reached the moderate category, as Hake (2002) stated in table 3.

Table 3. Category of score acquisition

Boundary	Category
$g > 0.7$	High
$0.3 \leq g \leq 0.7$	Medium
$g < 0.3$	Low

The reliability of this MMAGT is not yet high because it is still being repaired or developed. Improvements will be made to the media by paying attention to the media test results users to find out the user's student responses about the readability of the media. Other improvement or development processes are also carried out by considering the test results of media experts and Material Experts to find out the shortcomings that must be corrected to obtain perfect learning resources and media according to the experts before being applied to the actual test.

3.1. Media Form Trial (Student Response)

*E*MMAGT made in this study was tested limited to determine student responses or opinions regarding the use of animated multimedia in learning activities. The results are shown in Table 4.

Table 4. Student response to MMAGT

No.	Aspects	Feedback/ Assessment			
		STS	TS	S	SS
1	Display *E*-MMAGT is good and attractive	0	1	16	8
2	Content *E*-MMAGT is good and interesting	0	1	15	9
3	The material in *E*-MMAGT is easy to understand	0	0	16	9
4	Animations/images are easy to understand	0	0	11	14
5	*E*-MMAGT is easy to operate	0	1	15	9
6	*The link* on *E*-MMAGT works well	0	1	16	8
7	Learning resources and media with *E*-MMAGT make it easier for students to learn	0	0	13	12
8	Learning resources and media with *E*-MMAGT makes it easier for students to understand the material/lessons	0	1	15	9
9	Sources and learning media with *E*-MMAGT are needed for students	0	0	15	10
	Total	0	5	132	88
	Percentage (%)	0,0	2,2	58, 7	39.1

Description:
SST = Strongly Disagree
TS = Disagree
S = Agree
SS = Strongly Agree

3.2. Media Form Trial (Student Response)

Based on the analysis of the questionnaire results given to 25 students in the experimental class. The number of items in the student response questionnaire was nine statements; from the student response questionnaire, after using the MMAGT obtained as much as 0% Strongly disagree, 2.2% Disagree, 58.7.% Agree, and 39.1% Strongly agree. So from these results, it can be seen that as many as 58.7% Agree and 39.1% Strongly agree that using MMAGT is more exciting and, of course, makes it easier to understand technical drawing material. Thus, learning with multimedia animation on technical drawings will facilitate the student learning process.

In general, the students' responses were either by assuming or giving an assessment of agreeing or strongly agreeing to the use of MMAGT. A total of 97.8% of students rated MMAGT as good, attractive, easy to understand, and easy to operate, making it easier for students to learn and understand the subject matter so that students require MMAGT. Associated with the preliminary study results, the use of MMAGT appears to be in contrast to being highly desired by students because students want to develop material that is easy to obtain, interesting, and not boring. In terms of learning resources and learning media that have been used by teachers, in general, they use books so that MMAGT becomes fresh water to quench the thirst for students who have been wanting something new and better and interesting. In terms of motivation and confidence to master the material better, MMAGT is the primary choice for students.

3.3. Wider Trial

3.3.1. Description and Data Processing of Wider Trial Results The

the more comprehensive trial is intended to test the media made due to refinement after the limited test, which includes improvements in appearance, readability, and sound. In addition, improvements are also made due to the Expert validation test, which includes the depth of the material and the suitability of the indicators with the material and questions. This more comprehensive test was carried out in one class, namely the Mechanical Engineering expertise study program students, totaling 25 people. The results of this more comprehensive trial are presented in table 5.

Table 5. Calculation results of a more comprehensive trial

Data	Score	
Pre-Test	Highest	60
	Lowest	10
	Average	33.00
Post-test	Highest	100
	Lowest	51
	Average	80.39
N-gain (%)	Highest	100.00
	Lowest	34.67
	Average	72.38

3.3.2. Discussion of Wider Trial Results

From a more comprehensive trial, it can be seen that the average *N-Gain* is 72.38 on a scale of 100 or 0.7238. This is evidence that this media can improve students' ability in the high category (Hake, 2002).

The reliability of this media increased from the previous medium category to the high category after undergoing a process of improvement or development. The improvement process is carried out by paying attention to *a student* about the readability of the media as a result of media testing to users. In addition, other improvements were also made after paying attention to the results of media expert tests to obtain perfect media according to media experts and material experts. MMAGT approved by media experts and material experts, is proven to increase students' abilities to reach the high category in a broader test. Media used in the broader test has been refined even if it is only a final polish by maximizing the input of experts in the previous stage in terms of the perfection of appearance, image, sound, and suitability of the material. The media that is considered perfect is then used to test the validation of the media.

3.4. Validation Test

3.4.1. Description of Data Validation Test Results

The research was conducted on YAF Technology Vocational School students in Banjar City with the number of samples in each class, namely Class XA for the Control class and Class XB for the experimental class. Student data is processed based on pre-test scores and post-test scores. The data that was processed was the data of students who took a series of pre-test and post-test assessments, which were then used to describe quantitatively as the basis for concluding the results of the research conducted.

Data was obtained from technical drawing material for concept mastery, especially orthogonal projection material. Pre-test and post-test data in control and experimental classes were used to calculate the *N-Gain,* which increases students' abilities. The N-gain value is presented as shown in table 6.

Table 6. Calculation results of the pre-test, post-test, and *N-gain* mastery of the concept of orthogonal projections

Data	Highest	Class	
		Control	Experimental
Pre	-	50.00	65.00
	Lowest	10.00	10.00
	Average	25.28	33.16
Post Test	Highest	70.00	100.00
	Lowest	30.00	75.00
	Average	45.83	86.05
N-gain (%)	Highest	42.86	100.00
	Lowest	7.69	61.54
	Average	27.64	80.68

3.4.2. Data Processing Validation Test Results

The research data processing is based on the pre-test and post-test scores for the control class and the experimental class. The processed student score data is complete student data following the pre-test and post-test. The data is used to describe quantitatively as a basis for concluding.

The pre-test and post-test result data were taken from students' learning outcomes about mastering the concept of orthogonal projection, which includes American projection material and European projection. The processing of orthogonal projection data (American projection and European projection) is shown in a diagram as shown in Figure 3.

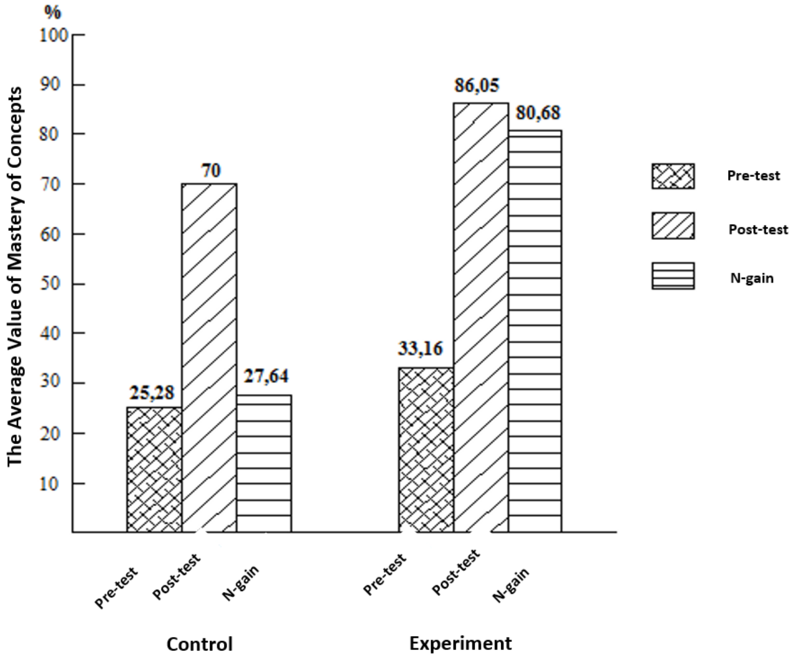

Figure 3. The value of mastery of concepts

The results of the calculation of mastery of concepts for the orthogonal projection material for the control class expressed in the minimum completeness criteria (KKM), the results obtained are as follows: (a) pre-test scores: 10 for the lowest score, 50 for the highest score, and 25.28 for the average score, all of which still do not meet the KKM; (b) post-test scores: 70 for the highest score, 30 for the lowest score, and 45.83 for the average score, all of which still do not meet the KKM; (c) *N-gain*: 7.69 for the lowest score in the low category, 42, 86 for the highest score in the low category, and 27.64 for the average score in the low category.

The results of the experimental class calculations for concept mastery obtained: (a) pre-test scores: 10 for the lowest score, 65 for the highest score, and 33.16 for the average score, all of which still do not meet the KKM; (b) post-test scores: 75 for the lowest score, 100 for the highest score, and 86.05 for the average, all of which have been declared to meet the KKM; (c) *N-gain percentage:* 61.54 for the lowest score in the medium category, 100 for the highest score in the high category, and 80.68 for the average score in the high category.

Based on the data processing results, an overview of increasing mastery of the concept of orthogonal projection material using multimedia animation engineering drawings (MMAGT), reaching an average value of 80.68 or reaching the high category. The increase in grades using the MMAGT is higher if students learn in the way that has been done so far in schools where the increase in average scores is only 27.64 or reaches the low category. Multimedia animation technical drawing (MMAGT) is proven to increase mastery of the concept of orthogonal projection material to high categories.

Several things that can be obtained from the findings of this study are that the multimedia animation developed is effective in providing concept reinforcement to vocational students. Multimedia animation is an effective medium for increasing the ability to master the concept of vocational students. Multimedia animation that is specially designed will make it easier for students to understand the material because it is displayed through good visualization. Good visualization can affect students' understanding of the material used. This is following the research results by Chiou, Tien, & Lee (2015) that research using animation media will make it easier for students to understand the material. In addition, its repetitive nature makes it easier for students to learn the material independently so that students can learn anytime and anywhere. In addition, the use of multimedia animation can encourage students' enthusiasm for learning. This is to research (Bustanil & Ardianto, 2019) and (Bustanil & Ardianto, 2019), which conclude that animated media using information technology applications can encourage students' motivation to learn. It is necessary to use this animation to continue to be developed for vocational students in the hope that vocational students can improve their abilities. In addition, the easy-to-use nature of animated media can help students learn easily anywhere and anytime.

4. CONCLUSION

The results of research in developing Multimedia Animation Engineering Drawing (MMAGT) have been carried out by Borg and Gall. The first step in this development focused on developing the initial product, which was initiated by preliminary research to determine the form of MMAGT required by students, which was finally tested to determine its reliability before use. At the same time, MMAGT functions as a learning resource and learning media. As a learning resource, MMAGT has the following characteristics: easy to have in a simple, inexpensive, but high capacity form; it contains complete material in Indonesian that is easy for students to understand.

Mastery of technical drawing concepts, especially mastery of orthogonal projection concepts, each increased to a high category using MMAGT. This increase is higher than using image media or *handouts*, which reach the low category. Thus, MMAGT is proven to increase mastery of technical drawing concepts, especially orthogonal projection material, to the high category. This research is only limited to technical drawing material, and it is necessary to develop other animation media on materials other than technical drawing. This is important because if the developed media already exists, it can be used in preparing online learning if it occurs, as was experienced during the COVID-19 pandemic. Therefore, it is necessary to form a team per topic of discussion to develop animation-based multimedia.

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