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Development of Product-Based E-modul of Manufacturing Helical Gears in Mechanical Engineering

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Abstract The general objective of this study was to develop an e-module of manufacturing helical gears on milling machines, and the specific objectives of the study consisted of: (1) describing the development steps of the e-module, and (2) analyzing the users' responses to the e-module. This study involved the development steps of the ADDIE model including analysis, design, development, implementation, and evaluation. A likert scale with four variations of answers was used in this study. The data were analyzed by quantitative descriptive and inter-rater reliability. The results showed that the developed product-based e-module have fulfilled good criteria of materials, media and feasibility from the users. The results revealed that: (1) the e-module was considered very good by the material experts in the aspects of self instructional, self contained, stand alone, adaptive and user friendly with the feasibility percentage of 94.16%. Furthermore, the media experts also assessed the e-module as good with the feasibility percentage of 80% in the ascpects of verbal, visual, programming and module component; (2) the users' response was very good with the feasibility percentage of 85.39%. The accuracy level was also good based on the teachers' evaluation with a mean score of 0.729.

Keywords: *e-module, product based, learning media*

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1. Introduction

Education is a conscious and planned effort to create a learning atmosphere and process thus students actively develop their potential to have religious spiritual strength, self-control, personality, noble moral, intelligence, and skills required by themselves, society, nation and country [1]. Education is important in developing the potential that exists in every human being to prepare themselves in the future. Referances [1] shows, "Types of education include general, vocational, academic, professional, religious and special education." Vocational education is distinguished in the level of implementation of education. They are carried out at the secondary school level and the high education level. Vocational education provides students with a variety of skills and knowledge to do certain jobs required for themselves, the world of work, and for the nation [2]. Rupert Evans in ([3]: 36) explains that the purpose of vocational education is to: (1) Meet the needs of the community for labor; (2) Increase education choices for each individual; and (3) Encourage motivation to continue learning.

The definition of Vocational High School is "Vocational High Schools, hereinafter abbreviated as VHS, is one form of formal education unit that organizes secondary education as a continuation of primary education, or other forms equivalent or advanced learning outcomes that are recognized as equal or equivalent to middle schools" [4]. VHS is an educational institution that has the potential to prepare human resources to be absorbed by the workforce, because applied theoretical and practical materials has been given since the first time entering VHS. It is expected that graduates have competence in accordance with the needs of the world of work [5]. Vocational education as well as technical education, occupational education, and vocational education, all of them have a similar goal to prepare graduates ready to work their respective fields [6].

The basic curriculum and curriculum structure of the Vocational High Schools are six expertise for mechanical skills competencies [7]. The six subjects are Manufacture Engineering Drawing, Lathe Machines, Milling Machines, Grinding Machines, NC/ CNC and CAM Machines, Creative Products and Entrepreneurship. Mechanical engineering teaches how to produce technical goods with various machines. Milling Machines is one of the competencies taught in the field of mechanical engineering. It teaches students in a comprehensive manner from the aspects of cognitive, affective and psychomotor, thus students are expected to be able to develop their own talent.

Based on the results of observations at SMK Negeri 2 Klaten, milling machines competency has three sub-competencies, namely straight gears, helical gears and

umbrella gears. In terms of the implementation of learning, the skill expertise competency is carried out in 5th to 6th semester with the allocation time of 6 hours lessons. Learning in the third year of Vocational High School often faced a problem in the allocation of time due to preparation for the National Examination. Inadequate learning tools such as lesson plans, modules, and media also obstruct the teaching and learning process. In the implementation of learning, the teacher delivers the materials verbally and still uses the overhead projector (OHP) so that it does not attract students' interest in learning. The implementation of the 2013 Curriculum which has not been maximized has blocked the use of the scientific approach. Even though the teacher has been able to arrange lesson plans based on scientific approach, they are not implemented in practices and the classes still uses the Education Unit Level Curriculum learning.

Sub competencies that cannot be accomplished are on manufacturing helical gears due to inadequate workshops facilities and the level difficulty of this competency. Thus the process of implementing learning becomes incomplete because these sub-competencies can not be taught completely. Inadequate facilities in the workshop resulted in less effective learning process because students learn by grouping on one machine with one student operating the machine and the other students just observing. Sudiyono [8] suggested that every education unit must have the facilities and infrastructure to support a regular and continuous learning process. Adequate facilities and infrastructure will have a positive impact on the success of students in obtaining sufficient information, knowledge, and skills as an effort to prepare themselves to enter workplaces in accordance with the demands required by the world of work and provide sufficient provisions for students to develop themselves and become part of society. The problems can be reduced with good learning management through applying the appropriate media to increase students' learning interest.

The development of instructional media is important to optimize the allocation of time for improving learning management, and encouraging students to master the competencies. To overcome the problems, it is necessary to develop teaching materials that is able to motivate students to be active in the learning process. Learning media are used to facilitate the learning process. Wirawan [9] suggests that the use of learning media is a very important factor for improving students' learning outcomes, because learning media is one of the tools that is very supportive in the development of knowledge, especially in the learning process in schools thus the teacher is required to use media adapted to current technological developments. The use of books or modules in electronic format or better known e-books can be used as a substitute for conventional books or documents without reducing their role as information [10]. Modules can be transformed into electronic forms so that they are given the term electronic module. The use of this electronic module can help students understand more thoroughly, improve student activity, and can be used to study independently outside of schools, so that it can improve students' learning outcomes. E-modules can be used with a computer or with an android application as an electronic media. Hamid [11] showed that the use of electronic modules increased students' interest in learning.

In addition, learning methods are needed to improve the students' ability to solve problems. One of them is product-based learning. Project Based Learning materials are teaching materials that can motivate students in the learning process. Thomas [12] states that the development of Project Based Learning e-modules is a learning model that organizes classes in a project. Yunus [13] explaines further that project based learning is effective to improve students' understanding. Yaron's [14] also added that the implementation of project based learning in technology learning can motivate students to increase activities in participating the learning process. The application of Project Based Learning can improve cognitive learning outcomes [15] and effective learning [16]. The e-module was developed so that students can learn independently without full guidance from educators who are only facilitators. The results of other studies on the application of E-modules based on Project Based Learning showed that it was able to improve learning outcomes [17] and students' learning interest [18]. Thus e-modules are used as teaching materials that can replace the functions of educators. If the educator has a function to explain, then the e-module must also be able to explain in a language easily accepted by the students appropriate with the level of the students'knowledge and age ([19]: 104).

Thus the learning media for manufacturing helical gears on milling machines must be effectively arranged, thus the learning process achieve its goals and objectives. Therefore, it is necessary to develop product-based electronic learning media for manufacturing helical gears on milling machines in SMK Negeri 2 klaten, which is expected to help teachers in delivering materials and assist the students to master the competencies taught.

2. Methods

This study was research and development. Sugiyono ([20]: 407) states that Research and Development is a research method used to produce certain products and test the effectiveness of the products. The learning media development model used in this study was adapted from the ADDIE development model. It serves as a guideline in building training tools and infrastructure programs that are effective, dynamic and support the performance of the training itself. The ADDIE development model consists of five stages, namely Analysis, Design, Development, Implementation, and Evaluation. The ADDIE development model is one of the effective development models used in the learning environment to develop products in the form of teaching materials [21].

The subjects of the trial in this study consisted of 2 subject groups. The first group was the subject for an internal rial that included 2 e-module validators, the material expert and media expert. Whereas the second group consisted of the teacher and students of Mechanical Engineering Department at SMK Negeri 2 Klaten who used the developed e-module. The instrument used was in the form of a questionnaire.

Data collection techniques and instruments consisted of expert validation sheets and product trial response sheets.

The expert validation sheet was a questionnaire used to obtain data about expert assessments. The results of this assessment were used as the basis for product improvement before testing. The e-module validation sheet was filled by material experts and media experts. The e-module validation sheet consisted of an e-module feasibility assessment sheet prepared using a Likert scale. The validity sheet was developed based on the e-module assessment instrument grid for material experts and media experts. The product trial response sheet was used to determine the response of teachers and students. Products developed need testing by using instruments to determine the accuracy and stability of the instrument. Testing can be conducted with providing the validity and reliability of the instrument. One formula that can be used to measure the reliability of an instrument with a non-diatomic score (eg a score of 0 to 4) is the Alpha formula. To examine the level of reliability, it was used the reliability criteria presented in Table 1 [22].

Table 1. Reliability Correlation Coefficient

Coefficient Interval	Level of Reliability
0.80 – 1.00	Very high
0.60 – 0.80	High
0.40 – 0.60	Acceptable
0.20 – 0.40	Low
0.00 – 0.20	Very low

Data analysis techniques were analyzed by descriptive statistics. Descriptive statistics are statistics used to analyze data by describing or describing collected data as they are without intending to make conclusions that apply to general or generalizations ([23]: 169). In order for data to be used in accordance with the purpose of the study, the qualitative data was converted first based on the score (one, two, three, and four). The quantitative data were then analyzed by descriptive statistics. The scores obtained were then converted into four scales of feasibility categories described in Table 2.

Table 2. Scale of Feasibility Categories

Average Score Range	Category
Xi + (1.5 SBi) < X ≤ Xi +(3.0 SBi)	Very good
Xi < X ≤ Xi + (1.5 SBi)	Good
Xi - (1.5 SBi) < X ≤ Xi	Acceptable
Xi - (3.0 SBi) < X ≤ Xi - (1.5 SBi)	Poor

3. Results and Discussion

Product trials were carried out to determine the feasibility of the product. The product feasibility test was carried out in two stages. The first stage of product feasibility was tested on experts both material experts and media experts to validate the milling helical gear materials.The assessment of material experts was adjusted to the characteristics of the module which consisted of self-instructional, self contained, stand-alone, adaptive and user friendly.

Table 3. Assessment of Material Experts

No	Aspect	Score	Maximum score	category	Percentage
1	Self instructional	71	76	Very good	93,42%
2	Self contained	12	12	Very good	100%
3	Stand alone	7	8	Very good	87,5%
4	Adaptive	12	12	Very good	100%
5	User friendly	11	12	Very good	91,67%
Total		113	120	Very good	94,16%

Table 4. Evaluation of Media Experts

No	Aspect	Score	Maximum score	category	Prosentase
1	Verbal	13	16	Good	81,25%
2	Visual	61	80	Good	76,25.%
3	Programming	31	36	Very Good	86,11%
4	Module Components	7	8	Very Good	87,5%
Total Score		112	140	Very Good	80 %

Data from the assessment of all aspects in Table 3 by material experts is 113 out of the 120 maximum score or 94.16% with the category of "very good", so it can be concluded that the e-module is very feasible to be used.

The expert media assessment is adjusted to the characteristics of the module which consists of verbal aspiration, visual aspects, programming aspects and module component aspects.

From the data, the assessment of all aspects in Table 4 by media experts is 112 out of the 140 maximal score or 80% in the "good" category, so it can be concluded that the e-module is feasible to be used.

Product testing after evaluation by material experts and media experts was users testing. There were three teachers as assessors of the product, two of which are mechanical engineering teachers at SMK N 2 Klaten and one teacher is a mechanical engineering teacher at SMK Karya Dharma Veteran Teras Boyolali. The teachers assessed the materials, media and learning aspects of the e-module.

Evaluation data on the material aspects of e-modules can be seen in Table 5. From these data, the results reveal that all three teachers provide very good rating. In conclusion, in general the matery in the developed e-module is in the very good category. Evaluation data on the aspects of the media can be seen in Table 6. The results show that there are two teachers who provide very good rating and one teacher gives a good rating. From these data it can be concluded that in general the media in the developed e-module is in the good category. Evaluation data on the learning aspects of e-modules can be seen in Table 7. From these data, the results reveal that there are two teachers who provide very good rating and one teacher gives a good rating. In conclusion, in general learning using the developed e-module is in the good category.

Table 5. Criteria for Assessing Material Aspects

Respondents		Rating Number											Total	Category
	1	2	3	4	5	6	7	8	9	10	11		
Teacher 1	4	4	4	4	4	3	4	3	3	3	3	39	Very Good
Teacher 2	4	4	4	3	3	3	3	3	4	3	4	38	Very Good
Teacher 3	4	4	3	4	3	3	3	3	3	3	3	36	Very Good
Total													113
The ideal highest score (Max)													132
The ideal lowest score (Min)													33
Ideal average (Xi)													83
Ideal standard deviation (Sbi)													17

Table 6. Criteria for Evaluating Media Aspects

Resp.		Rating Number															Total	Category
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16		
Teacher 1	4	4	3	3	3	4	4	4	4	3	4	3	4	3	4	4	58	Very Good
Teacher 2	4	4	3	4	3	4	3	4	4	3	4	3	3	4	4	3	57	Very Good
Teacher 3	3	3	3	3	3	3	3	4	4	4	3	3	3	3	3	3	51	Good
Total																		166
The ideal highest score (Max)																		192
The ideal lowest score (Min)																		48
Ideal average (Xi)																		120
Ideal standard deviation (Sbi)																		24

Table 7. Criteria for Assessing Learning Aspects of E-modules

Resp.		Rating Number										Total	Category
	1	2	3	4	5	6	7	8	9	10	11		
Teacher 1	4	3	3	4	4	3	4	3	4	4	4	40	Very Good
Teacher 2	4	3	3	4	3	3	3	3	4	4	4	38	Very Good
Teacher 3	3	3	3	4	4	2	2	3	3	3	4	34	Good
Total													112
The ideal highest score (Max)													132
The ideal lowest score (Min)													33
Ideal average (Xi)													83
Ideal standard deviation (Sbi)													17

The product trial evaluation data on the three teacher respondents were then analyzed to find out the consistency. The assessment model was developed based on the value of the Cornbach Alpha (α). The results of the reliability analysis of this evaluation model can be seen in Table 8.

Table 8. Analysis of Assessment Reliability

Reliability Statistics	
Cronbach's Alpha	N of Items
0,890	3

Based on the table of reliability analysis statistics it is known that the alpha cornbach value (α) is 0.890. From these data, it shows that the instrument has a very high level of reliability. These results are in accordance with the criteria for the reliability analysis in Table 9.

To measure agreement between respondents, it can be seen from vulnerable assessments in Table 10 as a parameter whether there is agreement between individual respondents to the assessment.

Table 9. Range of Cronbach Alpha Values

Range of Cronbach Alpha Values	Category
<0.20	Very Poor
0.21 – 0.40	Poor
0.41 – 060	Moderate
0.61 – 0.80	Good
0.81 – 1.00	Very Good

Table 10. Range of Kappa Coefficient Values

Range of Cronbach Alpha Values	Category
0.00 – 0.20	Poor
>0.20 – 0.40	Fair
>0.40 – 060	Moderate
>0.60 – 0.80	Good
>0.80 – 1.00	Very Good

Table 11. Table of Intraclass correlation coefficients

Intraclass Correlation Coefficient							
	Intraclass Correlation[b]	95% Confidence Interval		F Test with True Value 0			
		Lower Bound	Upper Bound	Value	df1	df2	Sig
Single Measures	0,729[a]	0,588	0,837	9,062	37	74	0,000
Average Measures	0,890[c]	0,811	0,939	9,062	37	74	0,000
Two-way mixed effects model where people effects are random and measures effects are fixed.							
a. The estimator is the same. whether the interaction effect is present or not.							
b. Type C intraclass correlation coefficients using a consistency definition. The between-measure variance is excluded from the denominator variance.							
c. This estimate is computed assuming the interaction effect is absent. because it is not estimable otherwise.							

Table 12. Students' Assessment

No	Aspect	Score	Maximum score	category	Percentage
1	Material	26.09	32	Very Good	81.53 %
2	Media	40.61	48	Very Good	84.60 %
3	Function	15.27	16	Very Good	95.45 %
Total Score		81.97	96	Very Good	85.39 %

Data from the scores analysis of the assessment of both material aspects. media aspects and learning aspects of e-modules by each teacher has a kappa coefficient value of 0.729. it can be said that each individual has a strong level of agreement. These results are in accordance with the kappa coefficient assessment criteria in Table 11.

The product trial was conducted on 33 XII grade students of SMK N 2 Klaten majoring in Mechanical Engineering. Aspects that were assessed by students included material. media and function.

Data from the assessment of all aspects in Table 12 by students is 81.97 from the 96 maximal score or 85.39% with the category of "very good". Thus it can be concluded that the e-module is feasible to be used.

Based on the assessment of the students. the comparison in each aspect can be seen in Figure 1.

In general. the final product of the milling helical gears e-module is feasible to be use after revisions and improvement according to the suggestions from the experts and users. The e-module can be operated on smartphones with an Android system so that they can be used anywhere without having to be connected to the internet. This product is also suitable to be used for independent learning because there are several supporting aspects to provide an overview to the users. namely video tutorials and illustration images that help the users to learn the materials.

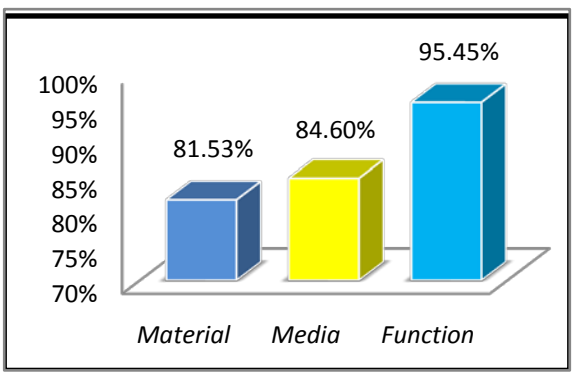

Figure 1. The percentage of students' responses

4. Conclusion

Based on the research finding on the e-module development. it can be concluded that the developed e-module were well prepared according to the 2013 curriculum with the scientific approach. The e-module were compiled using project based learning so that the content of the teaching materials shows the whole process from the beginning to the end to produce a product. They consisted of several components including (1) initial appearance; (2) introductory display; (3) material display; (4) formative test display; (5) videos; and (6) references. Product development was made in the form of adobe flas Player softwares and then converted from SWF format to Apk with a capacity of 99 Mb so that it can be operated on smartphones with the Android operating system.

The feasibility of e-module teaching materials is analysed based on the assessment from material experts. media experts and users' responses. The assessment from the material expert showed a very good with a percentage rating of 94.16%. From media experts. the percentage of assessment is 80% with a good category. In addition. the user responses from the students were very good with a feasibility percentage of 85.39%. The accuracy of the assessment results from the teachers has the criteria of "good" with a mean score of 0.729. General assessment of milling helical gears e-module teaching materials can be categorized as good and applicable.

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