Development of teaching materials for gas metal arc welding (gmaw) practice courses

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Abstract. In improving the quality of human resources, one of which lies in the quality of quality education. In this case, education has a very important meaning in human life, both in the life of individuals, nations, and countries. Therefore education must be implemented as well as possible so that it is following the objectives that have been planned. The objectives to be achieved from this study are to produce teaching materials for GMAW welding practice materials, produce teaching materials that are suitable for use in GMAW welding practices, and provide an evaluation of the effectiveness of using GMAW welding practice teaching materials after being used in learning. This research method uses the Borg and Gall development research method which is simplified into four steps, namely modified (simplified) into 4 steps consisting of: (1) preliminary study; (2) product development and validation; (3) limited trial; and (4) the final product. The type of research used in this research is the development of teaching materials in the form of practice modules, job sheets, and evaluation sheets in the GMAW welding practice course. Based on the research results, the researcher can conclude that the development of teaching materials for GMAW welding practices has been implemented properly. The revised results from the experts have been applied to the modules made so that the modules can be used properly by students.

1. Introduction
One of the efforts that can be made to improve the quality of human resources is through the implementation of quality education. In improving the quality of human resources, one of which lies in the quality of quality education. In this case, education has a very important meaning in human life, both in the life of individuals, nations, and countries. Therefore education must be implemented as well as possible so that it is in accordance with the objectives that have been planned. To be able to realize the goals of national education, namely developing the potential of students to become human beings of faith, caution, noble character, health, knowledge, competence, creativity, independence, responsibility, and democracy, can be achieved.

Mechanical Engineering Education Study Program (PTM) is one of the study programs in the Mechanical Engineering Department, Faculty of Engineering, Universitas Negeri Semarang. One of the compulsory courses that PTM students must take is Welding Practice II, which is a continuation of the
Welding Practice I course. In the Welding Practice I course, students are given welding material OAW (Oxy Acetylene Welding) and SMAW (Shielded Metal Arch Welding). While the material in the Welding Practice II course is welding GMAW (Gas Metal Arch Welding) and GTAW (Gas Tungsten Arch Welding). The purpose of the two courses is to equip students with knowledge and skills about various types of welding so that it is hoped that they will be ready when they graduate and become a teacher or work in industry or other fields.

The learning process is something that needs to be considered in the organization of a school institution from elementary schools to tertiary institutions. In implementing the learning process, a teacher certainly needs teaching aids in the form of teaching materials and learning media. The teachers can do everything to help their learners learn more effectively, developing teaching material is very important to increase the students’ skills from lower to the higher. Teaching materials are materials, information, tools, or media that can be used by a lecturer to carry out the learning process, including creating a conducive atmosphere for students to participate in learning. Martono states the use of learning modules can create effective learning processes and have an impact on improving learning outcomes. Media learning is everything that becomes a means of delivering information from the sender to the recipient so that what is delivered can be well received.

Based on the results of interviews and preliminary observations that have been made, during the implementation of the Welding Practice course, there are still problems with the availability of teaching materials to support the practice. This is because there is no introductory course in the form of welding theory or the like. In addition, the teaching materials that are already available are only presentation materials. This causes students to experience difficulties in carrying out practices, especially in terms of machine settings and welding parameters. Besides, students also experience problems when they have to learn independently about the welding material they have to do.

Modules are also called teaching materials for independent study because they include instructions for independent study. Modules are a set of teaching materials that are presented systematically so that their use can be studied with or without a facilitator or teacher. This means that readers can do learning activities other than on campus with lecturers and can also be done at home so that the module is referred to as independent instructional material. In addition, research conducted by Nurhadiyanto, Wagiran, and Mujiono concluded that with the help of modules it can improve the quality of learning and can reduce misconceptions in learning.

The main implication of independent learning activities is optimizing learning resources while still paying attention to students in controlling their learning activities. In developing modules, certain procedures are needed that are in accordance with the objectives to be achieved, a clear structure of learning content, and meet the criteria that apply to learn development.

Based on the description above, it is necessary to improve the learning process. One of them is through the development of teaching materials in the form of modules, job sheets, and evaluation sheets that can be used as support for both students and lecturers in carrying out Welding Practice lectures. In addition, the teaching materials that are prepared are also intended to be a means of achieving student competence in the field of welding. In order not to be too widespread, the material used in the development of this teaching material is the GMAW welding technique. This is done to adapt to student needs regarding mastery of GMAW welding material. In addition, it is also to match the development of materials in the industry where GMAW welding has begun to develop and is widely used. The aim to be achieved in this research is to produce teaching materials for GMAW welding practice courses that are feasible and easy to use by students.

2. Method
This research method uses development research methods. Development research methods are research methods used to produce certain products and test the effectiveness of these products. According to Darmadi, the main purpose of research and development is not to formulate or test theories but to develop effective results for use in school learning. The method in this research includes development models, development procedures, and product trials. The type of research used in this research is the
development of teaching materials in the form of practice modules, job sheets, and evaluation sheets in the GMAW welding practice course.

The development model used refers to Borg and Gall's [9] development research, defining research and development as a process used to develop and validate educational products. Borg and Gall [9], suggest 10 steps that must be taken in implementing development research. However, to suit the research needs and the limited research time, the 10 steps are modified (simplified) into 4 steps consisting of (1) preliminary study; (2) product development and validation; (3) limited trial; (4) the final product.

A preliminary study was carried out to determine the current conditions related to the implementation of welding practice learning. Activities carried out are by conducting literature studies related to lecture documents (RPS, modules, job sheets) and field studies related to implementing practices in workshops. Product development is carried out by reviewing the RPS, formulating indicators and learning objectives, collecting materials to be included in teaching materials; and product design. Teaching materials that have been prepared are then assessed by material experts and media experts. This validation activity is carried out to determine the feasibility level of the teaching materials that have been made. The next step is to conduct a limited trial on students who have taken welding practice courses II. This activity is also used to analyze the practicality of the teaching materials that have been made.

The types of data collection in this development research are qualitative and quantitative data. Qualitative data were obtained through reviews, input, and suggestions from experts. The qualitative data collection was carried out through interviews and consultations with lecturers and experts in the field of learning materials and media. Meanwhile, quantitative data were obtained from the results of the validation assessment of the product according to the scores compiled in the research instrument. The data that has been collected is then analyzed to obtain the feasibility level of the teaching material. The level of data feasibility is taken from the average score obtained from each material expert and media expert. The feasibility criteria can be seen in table 1.

| Average Score | Classification |
|---------------|----------------|
| 1 - 1.75      | Not feasible   |
| 1.76 - 2.50   | Quite feasible |
| 2.6 - 3.35    | feasible       |
| 3.36 - 4.00   | Very feasible  |

After the teaching materials were declared feasible by the experts, the teaching materials were then tried out on a limited basis with 22 students who had taken the mechanical practice II course. The purpose of this limited trial was to determine the level of practicality/ease of use of teaching materials. The data on the practicality of the teaching materials were then analyzed using a percentage formula, with criteria such as table 2.

| Percent        | Classification |
|----------------|----------------|
| 0% - 20%       | Not Practical  |
| 21% - 40%      | Less Practical |
| 41% - 60%      | Quite Practical|
| 61% - 80%      | Practical      |
| 81% - 100%     | Very Practical |
3. Result and discussion

3.1. Preliminary studies

The earliest step taken in the development of this teaching material is to conduct a preliminary study by means of field studies and literature studies. In the field study, it was carried out by means of observation and interviews with lecturers and students who were taking Welding Practice II courses. The purpose of this activity is to collect data related to the use of teaching materials that have been used in the learning process.

The results of interviews and observations indicate that so far the implementation of Welding Practices has not used adequate teaching materials. What students use as a guide is teaching material in the form of presentation files so that the material in it is very limited. Another finding obtained was that before taking the Welding Practice course, students had not received a preliminary course that discussed the welding theory. This causes students’ understanding of welding materials, especially GMAW welding, to be very limited. Currently, teaching materials that are available in addition to presentation materials are job sheets which also still need to be refined.

After conducting an observation, a literature study was carried out. At this stage, an analysis is carried out on the Semester Learning Plan (RPS) for Welding Practice II. This is done to assess the Learning Outcomes of Graduates and Learning Outcomes of Subjects which are used as references to determine the ultimate goal of learning. Furthermore, the results of the analysis are also used as a basis for compiling the teaching materials developed.

3.2. Product Development and Validation

The next step after conducting the preliminary study is the development of teaching materials. This is done with the intention of obtaining input from experts in the depth of content, form, and format of the teaching materials being developed. However, specifically for the format of teaching materials, it is adjusted to the format determined by Universitas negeri Semarang. The step taken is to conduct consultations with lecturers who teach welding practice courses and related experts. This was done to strengthen the research material in terms of the depth of content of the teaching materials that would be developed and later used by students in learning activities for GMAW Welding Practices. The steps taken are identifying existing RPS, identifying Subject Learning Outcomes and Learning Outcomes of Graduates according to the curriculum, collecting materials/references to strengthen the depth of the content of the developed teaching materials, and developing teaching materials.

Development activities carried out on this teaching material are the addition of enrichment materials, formative tests, and improving job sheet drawings and completing them with appropriate assessment standards. This is done so that this teaching material can be accepted and understood well by all lecturers and students who carry out practical courses Machining II. After the teaching materials are arranged, expert validation is carried out. The function of expert validation is to test the feasibility of a product developed before the product is used for further testing [10]. The results of expert validation are used as a basis for the improvement of the developed media. The experts here consist of two material experts and two media experts. Experts are asked to rate the module based on the previously prepared instruments. In addition to assessing the appropriateness of the teaching materials being developed, experts are also asked to provide suggestions on language style, layout, and clarity of tables and figures. The suggestions are then also used to improve/revise the teaching materials. The feasibility validation by material experts can be seen in table 3.

| Table 3. Results of material expert validation |
|-----------------------------------------------|
| Aspect                  | Indicator                                           | Average Score |
| Content                 | Conformity of material with learning outcomes       | 4             |
| Feasibility             | Accuracy of Material                                 | 3.7           |
|                         | Supporting learning materials                        | 3.8           |
|                         | Update of Material                                   | 3.5           |
|                         | Presentation Techniques                              | 4             |
Based on the data analysis in table 3, it can be seen that the results of the material expert's validation show that the teaching materials developed obtained an average score of 3.84 or were in the interval 3.36 - 4.00 so that they were included in the very feasible category. Broadly speaking, both the content feasibility component, the completeness of the presentation, and the language assessment related to the development of GMAW welding practice teaching materials can be categorized as very feasible. However, the validator also suggests adding an assessment sheet to each given job sheet so that students who use the module can find out the job sheet assessment criteria they are working on.

Likewise, the results of validation by media experts also show that the average assessment is at a score of 3.5 or is in the very feasible category. In general, the module size assessment component is in the very feasible category, but for designing the module content it is necessary to revise the layout of the module content section in the form of images and tables that need to be rearranged. Other than that, revisions made according to input from media experts are on the cover layout and module content to make it easier for users to read. Furthermore, after being rearranged the module is ready for use in learning. Assessment data by media experts can be seen in table 4.

| Component               | Indicator Component                          | average score |
|-------------------------|---------------------------------------------|---------------|
| Module Size             | Physical Module Size                        | 4             |
|                         | Module Cover Layout                         | 3             |
|                         | The letters used are attractive and easy to read | 4             |
|                         | Cover illustration of the teaching material  | 3.5           |
| Module Cover Design     | Layout consistency                           | 3.3           |
|                         | layout elements are harmonic                 | 3.6           |
|                         | layout elements are Complete                 | 3             |
|                         | the layout can speed up understanding        | 3.7           |
| Module Content Design   | The typography of book contents is simple     | 3.5           |
|                         | Typography is easy to read                  | 3.3           |
|                         | The typography of the book content makes it easy to understand | 3.6 |
|                         | Illustration of contents                    | 3.5           |
| Total Score             |                                             | **3.5**       |
3.3. Limited Trial
After the validity test was carried out by the expert and the teaching material was declared suitable for use in learning, then a limited trial was carried out. This limited trial is to determine the practicality level of the module based on the assessment of students who carried out Welding Practice II lectures in the odd semester of the 2019-2020 school year, as one of the users of the teaching material. The results of the practicality test can be seen in table 4.

| Parameters         | assessment results |
|--------------------|--------------------|
| The obtained score | 38                 |
| Maximum score      | 45                 |
| Percentage         | 84.4%              |
| Criteria           | Very practical     |

Based on the data in table 4, it shows that GMAW welding practice teaching materials are practical to use. This can be seen from the score obtained is 38 from a maximum score of 45 or has a percentage of 84.4%. So that the teaching material is included in very practical criteria. This can happen because the teaching materials developed have been equipped with worksheets and assessment sheets so that students can understand the criteria determined by the lecturer in working on worksheets.

In this limited trial, students also stated that the teaching materials were easy to understand, interesting, and could be studied repeatedly. This opinion is in accordance with the results of Handayani's research [11] which states that practical teaching materials are practical teaching materials that are easy to use so that they can increase student understanding.

3.4. Final Product Results
The final product produced is in the form of GMAW welding learning materials which are equipped with worksheets and practicum assessment sheets. In its preparation, this teaching material is further developed, namely teaching materials for students and teaching materials for lecturers. The difference is, lecturer teaching materials are equipped with answer key sheets for the formative tests given, while student teaching materials are not equipped with answer keys. This is done so that lecturers can use teaching materials more easily. Besides, in carrying out learning it becomes easier for lecturers to determine the practical work to be given and students can carry out the work given following the work steps described in the teaching material and can meet the criteria that are requirements for the practical assessment.

In accordance with these results, it can be concluded that the teaching materials developed are very practical to use, in accordance with the opinion of Rochmad [12] which states that the teaching materials that have been developed are said to be practical if the experts and practitioners state that theoretically that the teaching materials can be applied in field and level of implementation are in a good category. In addition, a sign of the practicality of printed teaching material is that it can be easily used in the teaching and learning process by teachers and students [13]. The practicality of this module is also supported by Hendra's [14] research which states that practical and effective modules in learning can improve student learning outcomes. Apart from the level of practicality, by using teaching materials that have a high level of validity, it is expected to increase behavior change in the cognitive, affective, and psychomotor domains of students [15].

The final result of the resulting product is a GMAW welding learning module which is equipped with a job sheet and practical assessment sheets. The module development process is carried out in stages and through expert validation tests. The experts involved in developing this module are material experts and media experts. In addition, a field test was also conducted to determine the effectiveness of the module being developed if it was applied in learning.

Initial data were obtained by conducting a preliminary study. This step is taken to collect initial data related to the learning of Welding II practices and what teaching materials have been used. In addition,
it is also to determine the development needs that will be carried out in this research. After obtaining field data, the process of making the initial module draft begins.

The draft module is then given to material experts and media experts for validity testing. In the validation stage by material experts, the mean validity score was 3.85. If converted to a predetermined scoring guide, the module that has been developed is in a very good condition / very feasible to use. However, revisions still need to be made to the current part of the material and presentation support. In addition, the validator also suggests adding an assessment sheet to each given job sheet so that students who use the module can find out the job sheet assessment criteria they are working on. This is in line with the opinion of Daryanto [16] who states that in a module it must at least contain learning objectives, material, and evaluation.

Further validation is carried out by media experts who assess the appearance aspects including size, cover design, and module content design. The average score obtained was 3.5. Based on the specified criteria, the evaluation of media experts is also in a very feasible category. Revisions made according to input from media experts are on the cover layout and module content to make it easier for users to read.

After it is declared valid and suitable for use by material experts and media experts, then a practicality test is carried out on the teaching material. Based on the test results, it was obtained data that the teaching materials were in the very practical category with a percentage value of 84.4%. This can happen that the material that is in the previous teaching material is very limited so that students have difficulty understanding the material. In addition, the previous teaching materials had not been equipped with a job sheet assessment sheet and an assessment sheet, so that students had difficulty understanding the criteria determined by the lecturer in working on the job sheet.

In accordance with these results, it can be concluded that the teaching materials developed are very practical to use, in accordance with the opinion of Rochmad [12] which states that the teaching materials that have been developed are said to be practical if the experts and practitioners state that theoretically that the teaching materials can be applied in field and level of implementation are in a good category. In addition, a sign of the practicality of printed teaching material is that it can be easily used in the teaching and learning process by teachers and students [13]. The practicality of this module is also supported by Hendra's [14] research which states that practical and effective modules in learning can improve student learning outcomes.

4. Conclusion

Based on the research results, it can be concluded that the development of teaching materials for GMAW welding practices has been implemented properly. The revised results from the experts have been applied to the teaching materials made so that the teaching materials can be used properly by students. In addition, the practicality assessment by students also gave excellent results with a percentage of 84.4% or it was in the very practical category to use.

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