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by Cek Turnitin Artikel Jurnal

Submission date: 09-Nov-2023 10:18AM (UTC+0700)
Submission ID: 2185998029
File name: 435-Article_Text-840-2-10-20221015.pdf (237.55K)
Word count: 4762
Character count: 25548

Italienisch
ISSN: 0171-4996, Vol. 12, No. 2, 2022, pp 958-964

Welding Training Program Development with Shield Metal Arc Welding (SMAW) Process

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Abstract

Welding is a technique for combining metals that involves melting a portion of the base metal with a filler metal to create a continuous connection. Training in SMAW (Shielded Metal Arc Welding) seeks to improve the welding abilities of community members. For this reason, researchers will investigate the development of training programs in the form of modules that can be utilized in teaching and learning SMAW welding practice topics. The employed research methodology is based on the development model, which consists of five stages: analysis, planning, design, development, and implementation. This development will be validated by content, language, and design validators. Ten students from SMK Widya Batam's class XI who major in welding engineering conducted the restricted testing. The SMAW welding module design validation results are 77.95%, the content is 79.14%, and the language is 78.55% of the criterion score, where the percentage, interpreted on a Likert Scale, is included in the correct criteria. Because of the evaluation, it can be determined that the resultant module is feasible and may be used to teach welding techniques. To evaluate the module's effectiveness, a limited trial was conducted with ten students of class X1 Las 1 who used the module and ten students of class X1 Las 2 who did not use the module. The test results of students who used the module yielded an average score of 89.22 percent, while the effects of student trials who did not use the module yielded an average score of 81.32 percent.

Keywords: *Welding, Shield Metal Arc Welding, Development, Training, Validation.*

INTRODUCTION

In this era of globalization, it requires everyone to have expertise because by having expertise, one will be able to withstand such tremendous pressure from the need for jobs that are not balanced with population development (Rizvi, 2007; Chalkiadaki, 2018) so that everyone is competing to improve knowledge and skills (Farr & Brazil, 2009; Sharma, 2018). Seeing this phenomenon, educators in educational institutions certainly have an essential role in increasing students' knowledge, skills, and entrepreneurial interests. At least educational institutions must prepare human resources who cannot only transfer theories related to their scientific fields. Nevertheless, able to provide a new paradigm to be realized in real life (Tymon, 2013 & Werner, 2021). One of the skills that are needed in the industrial world is welding.

Welding combines metals by melting the base and filler metal portions, with or without pressure and filler metal, and creating a continuous connection (Li et al., 2014; Pankaj et al., 2019). According to Ren & Liu's (2014) definition, welding is a metallurgical bond performed in a molten or liquid state at a metal alloy joint. Welding combines metals commonly used in the automotive, railway, plumbing, shipping, and bridge sectors, as well as attaching aircraft body panels (Deng et al., 2007; Giri et al., 2022). The public utilizes the welding connection method to join canopies, staircases, etc. (Bussell, 2007; Kidd et al., 2016).

The connection method using welding has advantages compared to other joints: straightforward and simple, the construction becomes lighter, the strength of the welded connection can approach or exceed the parent metal, and the welding connection technique is easy to operate and corrective actions if there is damage to the connection (Liew et al., 2019; Ma et al., 2021). In addition, the provision of knowledge/welding skills must be owned by the community that acts as a welder. Welder expertise will affect the quality of a good welding result if the welding ability is carried out properly and correctly according to welding technique procedures (Benyounis & Olabi, 2008; Jeffus, 2011).

The advantages of welding joints, among others, produce permanent results. Welded joints have a more muscular strength than the strength of the early material if the welding process uses added materials or fillers and welding methods properly and correctly (Tusek et al., 2001; Kashaev et al., 2018). Welded joints are also relatively economical when viewed economically. Welding can be used or tested in the field, not only in the factory area (Nowotny et al., 2007; Amancio-Filho & Dos Santos, 2009).

One of the welding methods is SMAW welding or shielded metal electric arc welding, one of the most straightforward and sophisticated welding techniques for welding structural steel (Ahmed et al., 2018; Qazi et al., 2020). This method is very widely used in shipbuilding and ship repair, in addition to an affordable price, also because welding with the SMAW method is very flexible in its use. Whether it is welding in a flat, horizontal, upright (vertical) position or a position above the head (overhead). SMAW welding is welding using electric power to power the electrodes (Sidhu & Chatha, 2012; Alkahla & Pervaiz, 2017). This welding is effective and practical because it only requires simple tools and electrical equipment to use in the home industry, such as making fences or in an industrial environment. In general, welding is used as a metal joint and maintenance tool for machine structures (Shahi & Pandey, 2008; Mvola et al., 2018). Things that harm health and safety must be considered in the welding process. The use of welding goggles, appropriate clothing, and safety shoes is a safe step in welding (Costella et al., 2009; Golbabaei & Khadem, 2015).

SMAW is the basis of the entire welding process. The certificate for SMAW welding consists of 3 (three), namely certificate one, certificate two, and certificate three. The core competencies needed to obtain all of these certificates are broadly the ability to: read sketches and or working drawings; use hand tools and light machinery; perform mechanical cutting; Weld the plate and pipe in the underhand/flat position, vertically/vertically, above the head/overhead, on the vertical axis it can be rotated, on the horizontal axis it can be rotated, on the horizontal axis it cannot be rotated, and on the inclined axis it cannot be rotated; weld plates and pipes in all positions with a combination of TIG (GTAW) and SMAW welding (Efendi et al., 2020; Stone et al., 2011). The qualification of a welder seems to depend on a combination of experience and skills of the welder on the shape of the workpiece, type of material, type of welding process, and welding position (Thomas et al., 1999; Williams & Parker, 2004).

Achieving SMAW welding competence requires a high budget for the materials used, time-forming competencies, and attitude skills that differ from the type of acetylene welding (Miller, 1997; Pate et al., 2012). So good planning is needed to carry out SMAW welding lessons. There are several problems encountered related to SMAW welding learning. Observations made at several educational institutions concluded that learning in SMAW welding still uses learning modules that are still monotonous, and there is no update of learning modules (Tulung, 2019; Ramadhan et al., 2021). Welding practice learning has so far been carried out with inappropriate practice media, namely media that are not adapted to students' safety and comfort conditions in completing the welding process. So that the learning achievement of welding produced is less than optimal (Munadi & Soeharto, 2019); Sisira et al., 2019).

Besides that, in the regular learning module, the teacher briefly explains the material that will be practiced on that day and then demonstrates it. This does not reinforce students in mastering the basics of welding techniques and work safety procedures in welding, so, in practice, some students carry out practicums with inappropriate procedures (Ardin & Mujiono, 2016). As a result, students become slower in completing the learning process. This can be seen when students do a practicum; each meeting should be able to carry out at least one welding process and weld with reasonable work safety procedures. However, what happened was not like that; for one welding process was completed in two to three meetings, we also carried out welding with less attention to proper work safety. If this continues, not all competencies needed by students can be conveyed and resulting in low student learning outcomes (Walintukan et al., 2020).

In addition, students also do not have guidelines to support increased understanding of the material presented, so the knowledge they get is only limited to explanations from the teacher and the student's notes; this causes students to have difficulty understanding and developing the material because there are no learning media. module) which supports the learning process that can motivate students to study harder. Even if students do not take notes, they will miss the material given by the teacher. Students cannot learn and even have difficulty understanding the material that has been delivered. Therefore, to maximize the quality of student learning outcomes, it is necessary to have a learning media that is expected to support the learning process.

METHOD

Research Target

This research targets the students of class XI Welding Engineering SMK Widya Batam. Who has taken the 2020/2021 SMAW welding practice subject.

Data collection technique

Utilizing a questionnaire and observation, this study collects data. The module validation questionnaire sheet is used to collect data from the evaluation findings of expert lecturers (validators) on the development process-created learning modules. This evaluation form is then used to update the created instructional modules. Several factors will be used in the evaluation, including the concept, module format, and quality of the modules generated. In addition, this study employed three language, design, and content specialists as assessors of the module validation questionnaire sheet.

Data analysis technique

The data analysis was done from the questionnaire sheet of expert lecturers with the following explanations: Expert Lecturer Questionnaire (Validator). The expert lecturers' questionnaire data analysis included the module's validation (language, design, and content). The data obtained from the validation results will be analyzed descriptively and quantitatively. The analysis method will be a percentage based on calculating the total value of the questionnaire data from expert lecturers. The assessment criteria are presented in the table below:

Table 1 Criteria Value Validation

Criteria	Value/Score
Not good	1
Pretty good	2
Well	3
Very good	4

RESULTS AND DISCUSSION

The results of the module validation which is presented in the form of a diagram below:

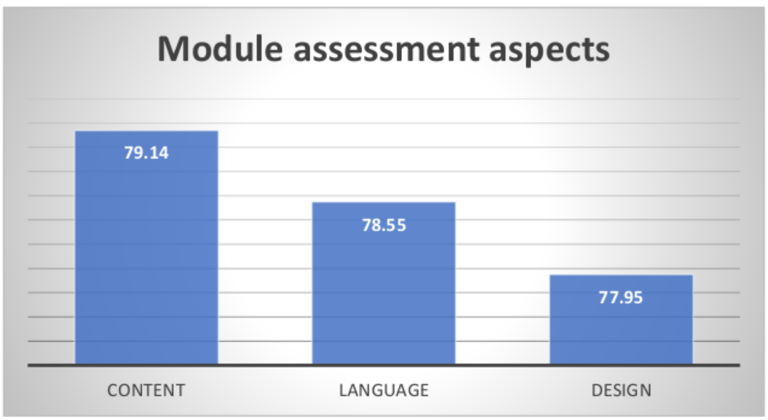

Figure 1 Diagram of module validation results

From the picture above, it can be seen that the percentage of the three assessments for the SMAW electric welding learning module is 77.95% for design validation which consists of 3 assessment indicators, namely module cover with a value of 75.00%, module format with a percentage value of 82.20% and illustration with a percentage value of 76.66% hence if the average percentage value of the three design aspect indicators reaches 77.95% and is included in the feasible category.

The module validation sheet also has a suggestion or input column that can be filled in by the module validator, where the suggestions and input are used as guidelines for module improvement/revision. The suggestions/inputs are as follows:

Table 2 Suggestions or Feedback by Design Expert Module validators

No	Suggestions/Feedback	Repair
1	The illustration on the cover is attempted to be even more attractive, display illustrations that support the content, simple but representative	The cover has been repaired according to the suggestion
2	The illustration on the cover is attempted to be even more attractive, displaying illustrations that support the content, simple but representative.	The cover has been repaired according to the suggestion.

Table 2 Suggestions or Feedback by the Content Expert Module validator

No	Suggestions/Feedback	Repair
1	Writing needs to be researched again because there are words that are not correct	The post has been corrected
2	The introduction should describe the material given in general in the module, the suitability of the material on the cover with the content of the material in the module; please write a bibliography reference.	It has been corrected as suggested.

Table 3 Suggestions or Feedback by the Linguist Module validator

No	Suggestions/Feedback	Repair
1	The signs in the instructions are given an exclamation mark, vocabulary, according to EYD, between text and illustration images must be balanced, and variations in illustrations and tables must be balanced evenly to the left, right, up, and down.	Everything has been corrected according to the suggestion
2	The language used cannot be understood, uses much non-standard vocabulary, and has an EYD error.	It has been corrected as suggested.

The learning outcomes of the student modules and the results of observations and observations of student learning activities regarding intellectual skills, particularly from the psychomotor domain in learning activities using the module, are used to determine whether the SMAW electric welding module that is made is effectual. This achievement of effectiveness is determined by the effectiveness of the SMAW electric welding module.

First stage limited trial

This limited trial phase was conducted to determine the feasibility and effectiveness of the modules in the form of increasing student learning activities by using modules. The limited trial was carried out in two stages. It aims to compare the data from the observations in the first phase of the trial with the data from the observations in the second phase so that it can be concluded whether there is an increase in a learning activity in the sample (students) or vice versa.

The technical implementation involves testing the module in the classroom and practicing in the workshop. The first stage was carried out; namely, the researcher conducted classroom learning on the sample (students) who used the module by giving pre-test questions to class XI Las 1 students to work on several pre-test questions and five essay questions for the second stage, the researcher gave the module for students to understand, for the third stage students are asked to work on formative questions by looking at the modules that have been given, for the fourth stage students practice welding in the 1G position at the Welding Engineering Workshop at SMK Widya Batam. Finally, students work on post-test questions without opening the module.

To determine the capability of student learning outcomes, the results of the learning scores of the sample (students) from class XI Las 1 were compared with class XI Las 2. According to the results of the learning outcomes of the sample (students) in the first phase of the limited trial, the average percentage of pre-test results was 75% for the sample (students) class XI Las 1, while the average percentage of free test results was 72% for the sample (students) students) XI Las 2. This demonstrates that the pre-test results of the sample (students) XI Las 2 have a difference of 3% when compared to the pre-test results of the average percentage of the pre-test results.

In the first phase of the limited trial, the sample (students) from class XI Las 1 had an average formative test result of 93%, while the sample (students) from class XI Las 2 had an average percentage of formative test results of 82.8%. These figures pertain to the learning outcomes of the sample (students) in the trial's first phase. This demonstrates that the results of formative test samples taken from students in XI Las 2 differed by 10.2% compared to the average percentage of formative test results.

The results of the average percentage value of the sample (students) XI Las 1 of 86.1%, and the results of the welding practice of the sample (students) of the XI Las 2 obtained a percentage result of 83%. This shows that the average percentage of practice results has a difference of 3.1% with the results of the sample practice (students) XI Las 2. Meanwhile, the results for the post-test score of the sample (students) XI Las 1 get 94.9% results, and the results for the sample (students) XI Las 2 obtained 79.5% results with a difference of 15.4%. The results of the module trial for the first stage in class XI Las 1 obtained good results. The difference between the results of class XI Las 1 and XI Las 2 shows the difference in the sample's objective (students) learning using classroom modules. The results of the observations of class XI Las 1 can be used as a guarantor and comparison of the results of class XI Las 2 so that the results of the observation of the module trial are declared objective.

Phase two limited trial

Technical implementation by testing the module in the classroom and practice in the workshop. The first stage was the researcher explaining how to use the module to several samples (students) who did not use the module, after that the researcher gave pre-test questions to class XI Las 2 students to work on; for the second stage, the researcher explained all the contents of the module to students, to in the third stage students were asked to work on formative questions, for the fourth stage students did welding practice with the 1G position. Finally, students worked on post-test questions without opening the module.

The implementation of the second phase of the limited trial is the same as the first phase. In this second limited trial, the average percentage of pre-test results was 79.2% for the sample (students) class XI Las 1, while the average percentage of pre-test results was 73.7% for the sample (students) XI Las 2. This shows that the average percentage of the pre-test results has a difference of 5.5% from the pre-test results of the XI Las 2 sample (students).

The average percentage of formative test results is 92.6% for the sample (students) class XI Las 1, while the average percentage of formative test results is 82.4% for the sample (students) XI Las 2. This shows that the percentage of the average formative test results has a difference of 10.2% from the formative test results of the XI Las 2 sample (students).

For the results of the average percentage value of the welding practice of the sample (students) XI Las 1 of 89.8% and the results of the welding practice of the sample (students) of the XI Las 2 obtaining the percentage result of 87.6%. This shows that the average percentage of formative test results has a slight difference of 2.2% with the results of the XI Las 2 formative test sample (students). In comparison, the post-test results of the XI Las 1 sample get 95.2% and the results for sample (students) XI Las 2 obtained 84.1% results with a difference of 11.1%.

Overall, the results of observations from both the first and second stages of the trial obtained good scores. The assessment results consist of a pre-test, formative test, practice assessment, and post-test of student modules. So that the results of observations by researchers can be objective. The difference in the observations from the first and second trial shows that the use of learning modules in the classroom has high effectiveness.

The percentage results indicate that the use of learning modules in class XI Las 1 is better and more effective than the results obtained that do not use modules in class XI Las 2. the two classes. The final score obtained from the pre-test questions and other questions in class XI Las 1 obtained an average percentage of 8 9.25% for the first stage of the trial and 89.2% for the second stage of the test of all the questions tested. Meanwhile, for class X1 Las 2, the final score obtained percentage of 81.32% for the first stage of the trial and 81.95% for the second stage of the test of all the test scores. This comparison of percentage gains shows that the effectiveness of using learning modules in class X1 Las 1 is better than those who do not use learning modules in class X1 Las 2. This can help students to improve learning outcomes with the SMAW Las learning module as a learning support medium.

CONCLUSION

Based on a series of actions conducted by researchers and the outcomes of research and discussion, the following conclusion can be drawn: The development of the SMAW electric welding module with welding practice material is suitable for use in class XI of the Welding Engineering Department of SMK Widya Batam, as determined by the module feasibility validation results (lecturer/teacher competence in content/substance, language, and design expertise). Based on the findings of the evaluation, the average percentages for content validation, language validation, and design validation were 79.14%, 78.55%, and 77.95%, respectively. The module is deemed feasible if it meets 61% of the current criterion value; therefore, based on the evaluation results, it can be stated that the resulting module is feasible and may be utilized as a teaching tool for welding practice courses. To determine the efficacy of the module, a limited trial was conducted with 10 students from class X1 Las 1 who used the module and 10 students from class X1 Las 2 who did not use the module. The test results of students who used the module yielded an average score of 89.22%, while the results of student trials who did not use the module yielded an average score of 81.32%. Based on the test scores, it can be stated that the designed SMAW welding module is practical for teaching welding techniques.

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