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Development of an SMAW Welding Textbook to Enhance Student Engagement and Cognitive Abilities

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Abstract

This study aims to develop a Shielded Metal Arc Welding (SMAW) textbook to enhance student engagement and cognitive abilities, assess its feasibility, and evaluate its impact on learning outcomes. The research employs a Research and Development (R&D) approach using the 4D model, consisting of Define, Design, Develop, and Disseminate stages. The subjects included 32 Grade XI TPL students at SMKN 2 Kota Serang, along with one media expert and one material expert as validators. Data were collected through expert validation questionnaires, student response questionnaires, engagement observation sheets, and pretest–posttest assessments. The developed textbook is aligned with the Indonesian National Work Competency Standards (SKKNI) and structured using a Problem-Based Learning (PBL) approach, complemented by Welding Procedure Specifications, job sheets, run sheets, and visual assessment rubrics. The feasibility results indicate a fair rating from the media expert (64%) and a high rating from the material expert (94%). Student

responses were very positive (83%). Cognitive improvement reached a moderate level (N-Gain = 0.6), and student engagement was categorized as very active (76%), indicating the textbook's effectiveness as a learning medium.

Keywords

SMAW Welding, Textbook, Student Activeness, Cognitive Ability, Enhance Student Engagement

Introduction

Learning and instruction are two interrelated components in the educational process. Learning is a conscious activity undertaken by individuals to obtain behavioral changes that encompass cognitive, affective, and psychomotor domains (Faizah, 2017). Meanwhile, instruction involves teacher–student interaction that produces changes in knowledge, attitudes, and thinking skills (Jusuf et al., 2020). Thus, learning and instruction constitute an integrated process that requires active student engagement and appropriate instructional management

In the context of Vocational High Schools (SMK), instruction must be directed toward producing graduates who are work-ready and professional. Teachers serve as facilitators who encourage students' active participation throughout the learning process (Hasri, 2021). The primary objective of SMK is to equip students with skills aligned with industrial demands (Alfia et al., 2023). Therefore, effective and participatory learning becomes a key determinant of success in vocational education.

The success of vocational learning is not solely dependent on psychomotor aspects, but also on students' cognitive and affective domains. Psychomotor competence can only be optimally developed when students possess adequate cognitive understanding and positive attitudes (Ermayasari et al., 2014). This indicates that the achievement of psychomotor competence

is strongly influenced by conceptual understanding and students' attitudes toward the learning material.

One of the core competencies taught in vocational schools is welding engineering, particularly in the Shielded Metal Arc Welding (SMAW) subject. SMAW instruction aims to equip students with technical knowledge of metal joining processes while ensuring competence in practical execution (Solahuddin & Susanti, 2023). This competency is highly demanded in the labor market, especially in industrial sectors (Amiruddin et al., 2022). Therefore, SMAW learning requires an appropriate instructional approach that ensures mastery of both theoretical knowledge and practical skills.

However, empirical findings indicate that challenges still persist in vocational learning practices. Low student motivation, limited engagement, and inadequate learning media continue to hinder learning outcomes (Nur'aini & Suwito, 2018). Moreover, students' practical performance is often suboptimal due to limited instructional facilities (Haryono et al., 2023). This demonstrates that non-interactive learning, coupled with insufficient learning media, has the potential to reduce students' achievements.

A preliminary survey conducted at SMKN 2 Kota Serang within the Welding Engineering expertise program involving 35 students supports these findings. The results revealed that only 54% of students actively answered questions and 50% took the initiative to ask questions. In terms of learning outcomes, 69% of students successfully completed project assignments, 70% successfully performed welding based on the Welding Procedure Specification (WPS), and only 59% were able to answer written and oral tests satisfactorily. From the perspective of learning media, only 50% of teachers provided learning media, 70% of

the media were relevant to the material, and 66% were categorized as effective. These findings indicate that low student engagement and cognitive performance are closely associated with suboptimal instructional media.

Based on the preliminary findings, it can be concluded that students' engagement and learning outcomes remain low and that the learning media used are not yet optimal. Teachers predominantly rely on conventional textbooks that are less structured and inadequate for complex subjects such as SMAW. Therefore, it is necessary to develop a more systematic SMAW textbook aligned with SKKNI and the Merdeka Curriculum, complemented with collaborative job sheets. The development of this textbook is expected to enhance both student engagement and cognitive abilities.

Method

This study employed a Research and Development (R&D) approach, which aims to develop and validate educational products that address practical needs in the field (Purnama, 2016). The selection of this method was based on preliminary findings at SMKN 2 Kota Serang, which indicated low student engagement and difficulties in answering test questions. Thus, there is a need for instructional media that can enhance student engagement and cognitive performance.

The development model adopted was the 4D model proposed by Thiagarajan et al. (1974), which consists of four stages: Define, Design, Develop, and Disseminate. Each stage was systematically executed to produce a feasible, effective, and practical instructional product. This model was selected because it aligns with the study's objective to develop a textbook capable of improving instructional quality.

Product trials were conducted following expert validation to determine the feasibility of the developed textbook. Validation was carried out by media and material experts using

questionnaires and assessment sheets. Subsequently, product effectiveness was examined through measurements of student engagement and cognitive improvement. Product practicality was assessed using student response questionnaires.

The study population comprised 65 students of class XI Welding Engineering at SMKN 2 Kota Serang, divided into two classes. A cluster sampling technique was employed to select one representative class (Firmansyah & Dede, 2022), resulting in 32 students from class XI Welding Engineering 2 as research participants.

Data were collected using questionnaires, observations, and tests. Questionnaires were administered to obtain expert and student responses regarding the textbook. Observations were used to document student engagement during learning activities. Tests were administered to measure students' cognitive performance following the implementation of the textbook. Each instrument was designed according to its respective objective and data requirement.

Result and Discussio

1. Define (Definition Stage)

One of the outcomes of this research is the structure and conceptual foundation of the SMAW Welding Textbook for the 2F welding position, which was developed based on needs analysis and learning outcomes. The textbook is designed to enhance students' cognitive abilities and engagement throughout the learning process. Structurally, the textbook consists of core instructional content aligned with the Indonesian National Work Competency Standards (SKKNI) and the Indonesian National Qualifications Framework (KKNI) level 2, and includes learning outcomes that emphasize mastery of both theoretical knowledge and welding practice in accordance with the Welding Procedure Specification (WPS).

To support the cognitive aspect, the textbook is equipped with run sheets that students must complete independently before starting practice. Meanwhile, to stimulate engagement, the textbook includes job sheets containing practical activity instructions and visual assessment rubrics that allow students to conduct peer assessment. All components in this textbook are designed to support the implementation of the Problem-Based Learning (PBL) model, which positions students as active participants in solving real-world welding problems.

Previous studies conducted by Febrianto & Puspitaningsih (2020) and Fitriah (2019) also developed textbooks; however, their products mainly contained material descriptions and focused only on expert feasibility validation, without testing instructional effectiveness in practice. Therefore, the SMAW Welding Textbook developed in this study has distinct characteristics compared to previous works because it refers to competencies stated in SKKNI, KKNI, Learning Outcomes, and Learning Objectives. Moreover, the textbook is structured with a theoretical foundation to support students' cognitive abilities and includes run sheets and job sheets containing collaborative tasks, making this research unique in measuring student engagement and cognitive ability through the use of the SMAW Welding Textbook.

2. Design (Planning Stage)

The design stage served as the foundation for developing the SMAW Welding Textbook for the 2F welding position. The textbook was designed in A5 format with 3-2-2-2 margins, using Calibri Light font size 11, and structured using Microsoft Word, while the cover was designed using Canva. The initial design considered both material and media feasibility, referring to Learning Outcomes (CP), Learning Objectives (TP), and

SKKNI, as well as responding to preliminary research findings regarding students' low engagement and cognitive performance.

The drafted textbook consists of several essential components, including the cover page, preface, table of contents, instructional content divided into three chapters, summaries, references, and a glossary. The main content of the textbook is structured to strengthen cognitive aspects and is equipped with illustrations, WPS, job sheets, and visual assessment rubrics. The WPS functions as a preparatory worksheet before practice, while the job sheets provide systematic practical procedures and assessment tools to enhance student engagement. All components support active student participation and reinforce independent understanding during learning. The textbook is also completed with summaries to help students grasp key concepts, a glossary to clarify technical terms, and references to acknowledge scientific sources used.

3. Development Stage

In the next phase, validation was carried out by media experts to evaluate the SMAW Welding Textbook from the media perspective. The validators were asked to assess the media feasibility of the textbook by completing the prepared questionnaires and providing comments or suggestions for improvement, if necessary, to refine the developed product.

Table 1. Media Expert Validation Guidelines

Percentage	Category
75,01% – 100,00%	Highly Feasible
55,01% – 75,00%	Fairly Feasible
41,01 % – 55,00%	Less Feasible

00,00 % – 40,00%	Not Feasible

Table 2. Results of Media Expert Validation

No	Aspect	Percentage	Category
1	Display	92%	Highly Feasible
2	Presentation	100%	Highly Feasible
3	Usability	75%	Highly Feasible
Average		92%	Highly Feasible

The media feasibility assessment consisted of three main aspects, namely display, presentation, and usability. Based on all aspects evaluated by the media expert, the textbook obtained a feasibility score categorized as Highly Feasible with a percentage of 92%, indicating that the SMAW Welding Textbook is suitable for use with minor revisions.

Based on material expert validation conducted to evaluate the SMAW Welding Textbook in terms of content quality, the validators were asked to assess material feasibility using a validation questionnaire and to provide comments or suggestions for improvement when necessary. The material feasibility assessment consisted of three main aspects, namely content feasibility, presentation, and evaluation. Based on all aspects assessed by the material expert, the material was categorized as Highly Feasible with a percentage score of 94%, indicating that the SMAW Welding Textbook is suitable for use, with recommended improvements.

According to Febrianto & Puspitaningsih (2020), one of the essential steps in the development stage is validation before implementation. This validation phase involves experts in the relevant scientific fields to ensure that the developed product meets the expected standards. Consistent with this, Hasanah et al. (2024) also state that during the validation stage, experts in the respective field must be involved to ensure that the developed product is appropriate and ready for use.

4. Disseminate (Distribution Stage)

To determine the effectiveness of the SMAW Welding Textbook, the researchers conducted an N-Gain test by administering a pretest to students before the learning process and a posttest after learning using the SMAW Textbook. The following data were obtained from the students' pretest and posttest results:

Table 3. N-Gain Effectiveness Guidelines

Persentase	Kategori
75,01% – 100,00%	Very Effective
55,01% – 75,00%	Moderately Effective
41,01 % – 55,00%	Less Effective
00,00 % – 40,00%	Not Effective

Table 4. N-Gain Calculation Results

Test	Mean Score	N-Gain Score	Percentage	Category
Pre-Test	33,59	0,6	60%	Moderately Effective
Post-Test	73,28			

Based on the results of the N-Gain test calculation, it was found that the N-Gain percentage obtained was 61%, with an N-Gain score of 0.6. This indicates that the SMAW Welding Textbook used in the learning process is proven to be moderately effective, falling into the medium N-Gain category.

As stated by Fitriah (2019), one way to improve students' cognitive abilities and learning outcomes is through the development of textbooks that are adapted to students' learning needs and difficulties. Furthermore, Hartini et al. (2018) also emphasize that students may experience an increase in material mastery and cognitive ability after learning using well-developed textbooks. These findings indicate that the use of textbooks can effectively enhance students' cognitive abilities because they help students better understand the learning material.

Furthermore, to evaluate the effectiveness of the SMAW Welding Textbook in terms of student engagement indicators, the researchers conducted classroom observations to assess student activeness during the learning process. The following data were obtained from observations using the student engagement observation instrument:

Table 7. Student Engagement Guidelines

Percentage	Category
75.01% – 100.00%	Very Active
55.01% – 75.00%	Active Enough / Moderately Active
41.01% – 55.00%	Less Active
00.00% – 40.00%	Not Active

Table 8. Observation Results of Student Engagement

NO	Indicator	Percentage	Category
1	Students listen to and take notes on the teacher's explanation	85%	Very Active
2	Students are not distracted by other situations during learning	81%	Very Active
3	Students actively answer the teacher's questions during learning	68%	Moderately Active
4	Students participate in concluding the learning outcomes	62%	Moderately Active
5	Students dare to ask questions to the teacher	81%	Very Active
6	Students dare to express opinions during learning	72%	Moderately Active
7	Students dare to present their work	81%	Very Active
Average		76%	very active

Based on the results of the student engagement observation, it was found that the percentage score obtained was 76%. This indicates that students were categorized as very active

after using the SMAW Welding Textbook to support the learning process.

According to Deriliana et al. (2017), during the learning process a student is considered active when they are engaged in classroom interactions, either with the learning materials or with peers. In the implementation of the SMAW Welding Textbook in this study, students were categorized as very active because throughout the learning process they fulfilled the indicators of student engagement as outlined by Putri et al. (2019).

Furthermore, to determine the practicality of the SMAW Welding Textbook—after previously going through media and material expert validation as well as effectiveness testing—an additional stage was conducted to examine students' responses to the textbook before fully evaluating its effectiveness. In this regard, 32 SMAW welding students were asked to complete a questionnaire as a form of response to the use of the SMAW Welding Textbook.

The assessment results across three aspects—content feasibility, presentation, and evaluation—show that the SMAW Welding Textbook is categorized as Very Good, with an overall score of 83%. This indicates that students responded very positively to the developed SMAW Welding Textbook.

In the development study conducted by Haspen & Syafriani (2022), it is explained that student responses refer to the extent to which the developed product is perceived as attractive and easy to use under normal learning conditions. Therefore, student responses are a crucial aspect in development research, as they provide direct insight into the usability and attractiveness of the product in real learning contexts.

Conclusion

The SMAW Welding Textbook for the 2F position was systematically designed using a Problem-Based Learning (PBL) approach to enhance student engagement and cognitive abilities. The textbook refers to SKKNI and KKNI Level 2 standards and includes instructional material, run sheets, job sheets, and visual assessment rubrics that support active and collaborative learning.

The textbook was declared feasible based on expert validation and student responses. The media expert provided a score of 64% (fairly feasible) with several recommendations for improvement, while the material expert awarded a score of 94% (highly feasible). Meanwhile, student responses indicated 83% (very good) due to the clarity and usefulness of the textbook

The use of the textbook demonstrated an improvement in students' cognitive abilities, with an N-Gain score of 0.6 (moderate category) and an effectiveness level of 60%. Student engagement also increased to 76% (very active category), influenced by the implementation of PBL, job sheets, and assessment rubrics that encouraged direct student participation.

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