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The freedom to learn-independent campus curriculum for shielded metal arc welding: A teaching module development

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Abstract: This study was triggered by the existing teaching modules for the Shielded Metal Arc Welding (SMAW) subjects taught at vocational high schools, which do not align with the Freedom to Learn-Independent Campus (FLIC) learning objectives, and do not provide a systematic organization. In order to enhance the learning experience, this research developed a new learning module that integrated Problem-based Learning (PBL), promoting critical thinking, and the practical application of theoretical concepts, following the FLIC curriculum. Utilizing a Research and Development (R&D) approach with the Instructional Design Institute (IDI) model, this study involved two welding instructors and four lecturers as validators to assess the content and usability of the module. The IDI model comprised three steps: instructional (define), development (develop), and institute (evaluate). The research findings regarding the validity assessment by subject matter experts yielded a final validity score of 0.924, while media and language experts provided a score of 0.936, meeting the valid criteria. The practical usability test of the learning module resulted in a score of 94%, indicating that it is highly practical for students to use as learning media. Based on the validity and practicality assessments of the developed module, it can be concluded that the SMAW learning module is highly practical to use as teaching media, aligning with FLIC curriculum.

Keywords: Quality education; Teaching material; Engineering students; Vocational education

1. Introduction

Vocational High Schools play a critical role in developing human resources with the skills, abilities, and expertise required for the workforce, preparing graduates to excel professionally in various fields (Rahim et al., 2024; Waskito, Wulansari, et al., 2024; Wulansari et al., 2024). Vocational education aims to equip students with competencies that align with scientific, technological, and artistic advancements, ensuring they enter the job market with a professional mindset. Achieving these educational goals relies heavily on implementing high-quality learning programs, necessitating an integrated approach involving teachers, students, conducive learning environments, and effective instructional media (Rasmitadila et al., 2021; Xu et al., 2022).

The teaching module is one of the most effective instructional media for vocational education. As self-paced learning tools, modules offer a structured format that supports independent study, following a curriculum that facilitates self-evaluation and improves comprehension (Al-Badi et al., 2022; Menggo et al., 2023; Won et al., 2023). Modules address several challenges in vocational settings, such as limited teacher time and space, and promote active student engagement with their learning environment (Al Mamun & Lawrie, 2023; Rajabalee & Santally, 2021). However, observations in the field, particularly in Shielded Metal Arc Welding (SMAW) techniques, reveal gaps in current module coverage. The existing modules do not fully align with the Freedom to Learn-Independent Campus (FLIC) curriculum learning objectives and are neither detailed nor systematically organized, prompting teachers to modify content manually—a process that risks diluting the effectiveness of knowledge transfer (Yu, 2024).

Given the internalization of knowledge central to the classroom experience, learning tools like modules must be comprehensive and engaging to enhance learning outcomes (Naicker et al., 2022; Qin, 2024). To meet the needs of SMAW learning, a suitable approach is Problem-Based Learning (PBL), which emphasizes problem-solving to foster critical thinking and deepen students' understanding (Okolie et al., 2022). PBL, as a method that encourages direct knowledge application, can stimulate motivation and improve students' grasp of the subject matter. Moreover, integrating Problem-Based Learning (PBL) with teaching modules complements the independent learning aspects of vocational education and introduces students to complex, real-world challenges that mirror workplace scenarios. This approach allows vocational students to apply theoretical knowledge practically, bridging the gap between abstract concepts and real-world applications—a critical factor in preparing them for the demands of the modern workforce. Additionally, by enabling students to explore solutions collaboratively, PBL fosters soft skills such as communication and teamwork, which are increasingly valued in today's job market (AlAli, 2024).

This study aims to address the limitations of current teaching modules by developing modules based on the FLIC curriculum for SMAW subjects in vocational education. By integrating Problem-Based Learning with these modules, this research introduces an innovative approach to elevate students' learning experiences, providing a robust and interactive framework that enhances understanding and application of the material. Additionally, this study seeks to evaluate the validity of these newly developed modules, which contribute significantly to vocational pedagogy by aligning instructional design with modern educational demands.

2. Methods

This research utilizes a Research and Development (R&D) approach, explicitly applying the IDI development model, structured in three main phases: Instructional, Development, and Institute (Spector et al., 2014), as illustrated in Figure 1. This systematic model ensures a comprehensive framework for creating compelling and scalable instructional tools to meet specific learning objectives and maximize educational outcomes.

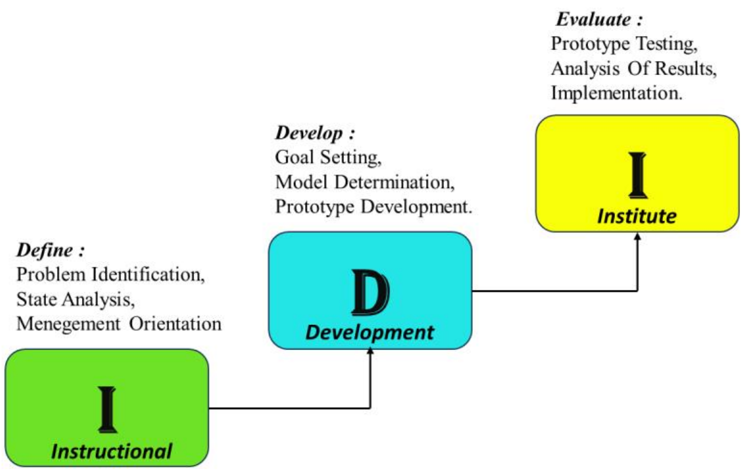


Figure 1. IDI model development procedure

In these phases, this study examines the instructional design process and evaluates its impact on student engagement and knowledge retention in a vocational setting. The novelty of this research lies in adapting and validating this model to suit specialized technical content, thus making it a pioneering approach to improving vocational learning modules.

Research subject

The research subjects included two vocational high school welding teachers and four lecturers from the Faculty of Engineering at Universitas Negeri Padang (UNP). The SMK teachers contributed as practitioners, providing practical insights into the module's classroom application, while the lecturers served as expert validators. Specifically, two lecturers were designated as material experts to evaluate content quality, relevance, and curriculum alignment, and two others assessed the module's media design and language clarity to ensure it met educational standards for usability and readability.

Data collection and instruments

The data collection instruments employed in this study consist of questionnaires and interviews. Three distinct questionnaires were designed to evaluate different aspects of the module: (1) a feasibility assessment by subject matter experts focusing on content accuracy and relevance, examining elements such as theoretical depth and practical alignment; (2) a media and language feasibility assessment that evaluates instructional clarity, visual appeal, and readability, ensuring the module's suitability for vocational high school students; and (3) a practicality assessment aimed at teacher-practitioners, capturing the ease of implementing the module in the classroom and its impact on student engagement (Fortuna et al., 2024; Waskito, Fortuna, et al., 2024).

The validators assessing this learning module possess extensive credentials, 30 to 40 years of teaching and research experience, and hold doctoral degrees and professorships (Syahril et al., 2021). Additionally, semi-structured interviews provided qualitative data, enabling participants to offer in-depth feedback on the module's practicality, adaptability in the classroom, and student interaction. The assessment questionnaires used by material, media, and practicality experts are presented in Tables 1, 2 and 3.

Table 1. Feasibility test framework for material experts

No	Aspects	Indicator
1	Self Instructional	1. General objectives and specific objectives
		2. Appropriateness of indicators, materials, and learning activities
		3. Relevance of exercises and evaluation questions
2	Self Contained	4. Contains all material for one unit of competency
		5. The order of the material
3	Stand Alone	6. Not dependent on other media
4	Adative	7. Flexibility of adaptation to technological developments
		8. Ease of instruction and material exposure
5	User Friendly	9. Use of good language rules
		10. Benefits of the module for teachers and students

Table 2. Feasibility test framework for media experts

No	Aspects	Indicator
1	Format	1. Paper format 2. Margin format 3. Module layout format 4. Format of marks
2	Organization	5. Completeness of module components 6. Structure of module material 7. Image/illustration layout
3	Attractiveness	8. Cover design 9. Module content design 10. Module color composition
4	Font shape and size	11. Clarity/readability of writing 12. Proportional letter comparison 13. Use of capital letters at the beginning of paragraphs
5	Blank spaces	14. Module cover spacing 15. Text spacing
6	Consistency	16. Writing consistency 17. Consistency of spacing 18. Layout

Table 3. Practicality test instrument

No	Aspects	Indicator
1	Self-instructional	1. General objectives and specific objectives 2. Appropriateness of indicators, materials, and learning activities 3. Relevance of exercises and evaluation questions
2	Self-contained	4. Contains all material for one unit of competency 5. The order of the material
3	Stand alone	6. Not dependent on other media
4	Adative	7. Flexibility of adaptation to technological developments
5	User friendly	8. Ease of instruction and material exposure 9. Use of good language rules 10 Benefits of the module for teachers and students

Data analysis technique

The data analysis approach employed in this study utilizes qualitative evaluation based on feedback collected from validators and practitioners through questionnaires. This evaluation is enhanced by applying V-Coefficient to assess validity, offering a statistically grounded index of agreement and relevance among expert reviewers (Aiken, 1985).

In addition, the analysis process examines the alignment between module content and pedagogical objectives, ensuring the instructional design supports engagement and knowledge retention. Further statistical measures were also considered to corroborate qualitative insights, refining the module's development for practical application in vocational education.

$$\mathcal{V} = \frac{\sum s}{n(c-1)} \qquad s = r - l_0$$

Description:

V: rater agreement index regarding item validity
n : number of validators
lo : limited validity assessment steps (in this case 1)
c : highest validity rating step (in this case, 5)
r: the number given by the validator
s: The score assigned to each reter is minus the lowest score in the category.

The V-Coefficient, calculated based on expert evaluations, is classified according to the categories displayed in Table 4. This categorization helps determine the validity levels of each item assessed by expert validators, supporting a comprehensive analysis of the instructional materials' quality and relevance.

Table 4. Module validity assessment categories

No	V-Coefficient	Category
1	0.667 - 1	Valid
2	<0.667	Invalid

Based on the analysis results, an overall average was derived, indicating the validity level of the teaching module, as illustrated in Table 5. This instrument employs a Likert scale for evaluation, allowing for a nuanced assessment of the module's practicality. Furthermore, the feedback collected from various stakeholders would be utilized to refine the module, ensuring it meets the diverse needs of learners and enhances the overall educational experience.

Table 5. Practicality categories based on teacher assessment

Assessment percentage (%)	Interpretation category
0% - 20%	Not Very Practical
21% - 40%	Not Practical
41% - 60%	Practical enough
61% - 80%	Practical
81% - 100%	Very Practical

3. Results

This research begins with a survey and needs identification at vocational high schools to address students' challenges in learning Shielded Metal Arc Welding. The survey revealed that the existing learning media failed to encompass all the material required according to the essential competencies, and the content was not presented in detail. To address these issues, a systematic learning module was developed, ensuring that the material is organized in a more coherent and accessible way. This aims to enhance students' understanding, increase motivation, and promote independent learning.

The development stage focuses on creating a design for the teaching module. During this phase, the module content is analyzed and compiled based on the Learning Outcomes (CP) and the Analysis of Learning Objectives (ATP) for the odd semester Shielded Metal Arc Welding Engineering course. Following this, the initial design of the module is drafted, which is essential before the validation process. At this stage, the module's format is developed, presenting a clear and user-friendly module display design that will facilitate practical learning experiences for students. This comprehensive approach ensures that the learning module meets educational standards and engages students effectively in their learning process. The results of the design and development of the Shielded Metal Arc Welding learning module are presented in Figure 2.

Figure 2. Appearance of the developed learning module for Shielded Metal Arc Welding

Figure 2 illustrates the outer cover of the teaching module, providing essential information about its contents. This includes various aspects such as the module's elements, learning outcomes, learning objectives, the Pancasila learner profile, facilities and infrastructure, target learners, and the learning models and methods employed.

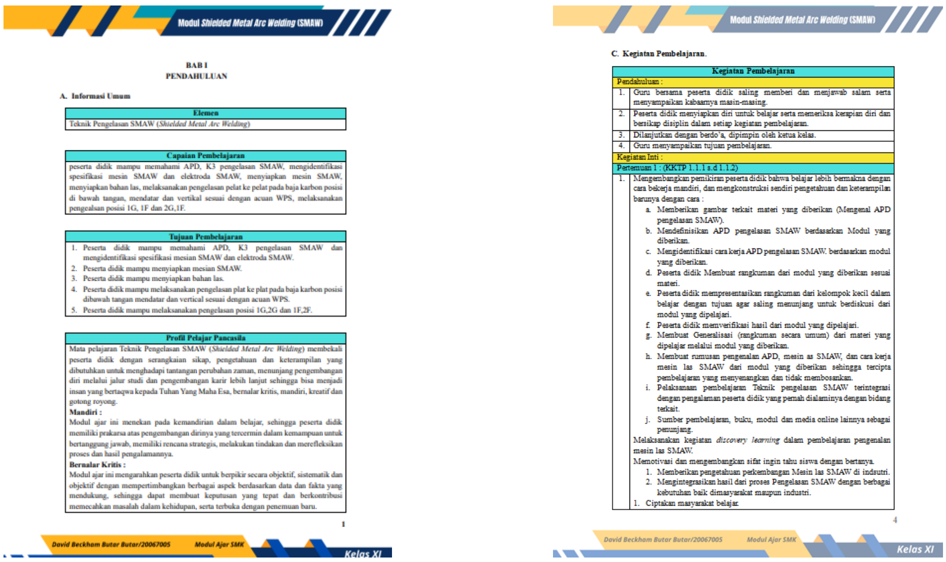
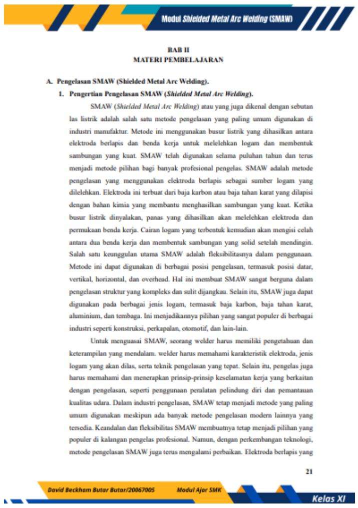


Figure 3. Presentation of chapter I: introduction and learning activities

Figure 3. depicts the layout of Chapter I, Introduction, which provides general information encompassing elements such as learning outcomes, objectives, the Pancasila learner profile, facilities and infrastructure, target learners, instructional models and methods, and detailed

learning achievements and goals. The learning activities outline the stages of the teaching process, including the introduction, core activities, and closing stages, which together form the instructional flow.


Modul Shielded Metal Arc Welding (SMAW)

BAB II
MATERI PEMBELAJARAN

A. Pengelasan SMAW (Shielded Metal Arc Welding).

1. Pengertian Pengelasan SMAW (*Shielded Metal Arc Welding*).

SMAW (*Shielded Metal Arc Welding*) atau yang juga dikenal dengan sebutan las listrik adalah salah satu metode pengelasan yang paling umum digunakan di industri manufaktur. Metode ini menggunakan busur listrik yang dihasilkan antara elektroda berlapis dan benda kerja untuk melelehkan logam dan membentuk sambungan yang kuat. SMAW telah digunakan selama puluhan tahun dan terus menjadi metode pilihan bagi banyak profesional pengelas. SMAW adalah metode pengelasan yang menggunakan elektroda berlapis sebagai sumber logam yang dilelehkan. Elektroda ini terbuat dari baja karbon atau baja tahan karat yang dilapisi dengan bahan kimia yang membantu menghasilkan sambungan yang kuat. Ketika busur listrik dinyalakan, panas yang dihasilkan akan melelehkan elektroda dan permukaan benda kerja. Cairan logam yang terbentuk kemudian akan mengisi celah antara dua benda kerja dan membentuk sambungan yang solid setelah mendingin. Salah satu keunggulan utama SMAW adalah fleksibilitasnya dalam penggunaan. Metode ini dapat digunakan di berbagai posisi pengelasan, termasuk posisi datar, vertikal, horizontal, dan overhead. Hal ini membuat SMAW sangat berguna dalam pengelasan struktur yang kompleks dan sulit dijangkau. Selain itu, SMAW juga dapat digunakan pada berbagai jenis logam, termasuk baja karbon, baja tahan karat, aluminium, dan tembaga. Ini menjadikannya pilihan yang sangat populer di berbagai industri seperti konstruksi, perkapalan, otomotif, dan lain-lain.

Untuk menguasai SMAW, seorang welder harus memiliki pengetahuan dan keterampilan yang mendalam. welder harus memahami karakteristik elektroda, jenis logam yang akan dilas, serta teknik pengelasan yang tepat. Selain itu, pengelas juga harus memahami dan menerapkan prinsip-prinsip keselamatan kerja yang berkaitan dengan pengelasan, seperti penggunaan peralatan pelindung diri dan pemantauan kualitas udara. Dalam industri pengelasan, SMAW tetap menjadi metode yang paling umum digunakan meskipun ada banyak metode pengelasan modern lainnya yang tersedia. Keandalan dan fleksibilitas SMAW membuatnya tetap menjadi pilihan yang populer di kalangan pengelas profesional. Namun, dengan perkembangan teknologi, metode pengelasan SMAW juga terus mengalami perbaikan. Elektroda berlapis yang

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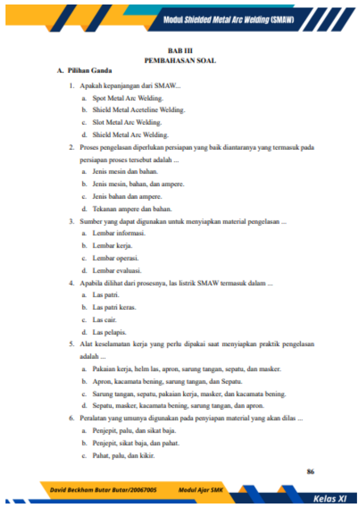
Modul Shielded Metal Arc Welding (SMAW)

BAB III
PEMBAHASAN SOAL

A. Pilihan Ganda

1. Apakah kepanjangan dari SMAW...
   a. Spot Metal Arc Welding.
   b. Shield Metal Aceteline Welding.
   c. Slot Metal Arc Welding.
   d. Shield Metal Arc Welding.
2. Proses pengelasan diperlukan persiapan yang baik diantaranya yang termasuk pada persiapan proses tersebut adalah ...
   a. Jenis mesin dan bahan.
   b. Jenis mesin, bahan, dan ampere.
   c. Jenis bahan dan ampere.
   d. Tekanan ampere dan bahan.
3. Sumber yang dapat digunakan untuk menyiapkan material pengelasan ...
   a. Lembar informasi.
   b. Lembar kerja.
   c. Lembar operasi.
   d. Lembar evaluasi.
4. Apabila dilihat dari prosesnya, las listrik SMAW termasuk dalam ...
   a. Las patri.
   b. Las patri keras.
   c. Las cair.
   d. Las pelapis.
5. Alat keselamatan kerja yang perlu dipakai saat menyiapkan praktik pengelasan adalah ...
   a. Pakaian kerja, helm las, apron, sarung tangan, sepatu, dan masker.
   b. Apron, kacamata bening, sarung tangan, dan Sepatu.
   c. Sarung tangan, sepatu, pakaian kerja, masker, dan kacamata bening.
   d. Sepatu, masker, kacamata bening, sarung tangan, dan apron.
6. Peralatan yang umunya digunakan pada penyiapan material yang akan dilas ...
   a. Penjepit, palu, dan sikat baja.
   b. Penjepit, sikat baja, dan pahat.
   c. Pahat, palu, dan kikir.

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Figure 4. Layout of chapter II: learning module content and chapter III: problem discussion

Figure 4 illustrates Chapter II of the learning module, which organizes the instructional content and study materials by session, spanning meetings 1 through 7. Practical sessions are conducted from meeting 8 through meeting 16, offering hands-on learning opportunities. Chapter III provides a comprehensive discussion of final semester exam questions, summarized from the materials covered in meetings 1 through 16. After developing a learning module as an educational medium, a feasibility or validity test is conducted by designated experts using a validated questionnaire to assess whether the module is suitable for instructional use. In order to confirm the module's validity and suitability, it undergoes an evaluation by validators. This assessment focuses on two main criteria: (1) the material content and (2) the media and language used. The module underwent validation by two material experts and two media experts from the Department of Mechanical Engineering at FT UNP. The feedback received from these experts was instrumental in revising the module for improvement. Subsequently, the data collected from the questionnaire was processed using Microsoft Excel.

Furthermore, the subsequent stages would involve validation by subject matter experts to ensure the module's content and format align with pedagogical best practices. Table 6 presents the validation results from the material experts, detailing their evaluations and suggestions for enhancement. This iterative process of validation and revision ensures that the teaching module meets educational standards and effectively supports student learning outcomes.

Table 6. Material expert validity results

No.	Assessment aspect	∑V	Description
1	Self-instructional	0.89	Valid
2	Self-contained	0.95	Valid
3	Stand alone	0.91	Valid
4	Adative	0.93	Valid
5	User friendly	0.94	Valid
	∑V	**0.924**	**Valid**

Table 6 presents the validity scores of the teaching modules as evaluated by several expert validators specializing in material content. The average validity score for material aspects reached 0.924 > 0.667, categorizing the module as "valid." This result confirms that the module's content aligns with educational standards, making it a reliable resource for students learning Shielded Metal Arc Welding. Based on this validation, the module meets content accuracy and supports clarity and relevance in achieving targeted learning outcomes.

Table 7. Media and language expert validation results

No.	Assessment Aspect	ΣV	Description
1	Format	0.93	Valid
2	Organization	0.92	Valid
3	Attractiveness	0.91	Valid
4	Font Shape and Size	0.91	Valid
5	Space (Blank Space)	0.93	Valid
6	Consistency	0.97	Valid
	ΣV	**0.935**	**Valid**

Table 7 presents the validation results of the teaching module, as evaluated by media and language experts. The scores for media and language aspects yielded an average validity value of 0.935 > 0.667, placing the module in the "valid" category. This high validity score demonstrates that the module meets essential standards for clarity, visual appeal, and instructional language, ensuring it is appropriate and accessible for vocational students. These findings indicate that the module is well-prepared to support student engagement and comprehension. Following this validation, further trials can be conducted in the classroom to assess the practicality of the module for teachers. These trials will provide insight into the ease of use of the module, its impact on student understanding, and its potential to facilitate learning based on the FLIC curriculum.

Table 8. Practicality test results for teachers

No.	Assessment Aspect	Percentage	Category
1	Self-instructional	96%	Very practical
2	Self-contained	91%	Very practical
3	Stand alone	91%	Very practical
4	Adative	93%	Very practical
5	User friendly	94%	Very practical
	Average	**94%**	**Very practical**

Table 8 presents the results of the practicality assessment of the teaching module conducted by practitioners. The module achieved an average practicality score of 94%, categorizing it as "very practical" for use in the learning environment. This high score indicates that the module is effectively designed for classroom application, facilitating ease of use and engagement for educators and students. Moving forward, this module can be further integrated into classroom settings, with ongoing evaluations to refine its instructional impact and adaptability to diverse learning needs.

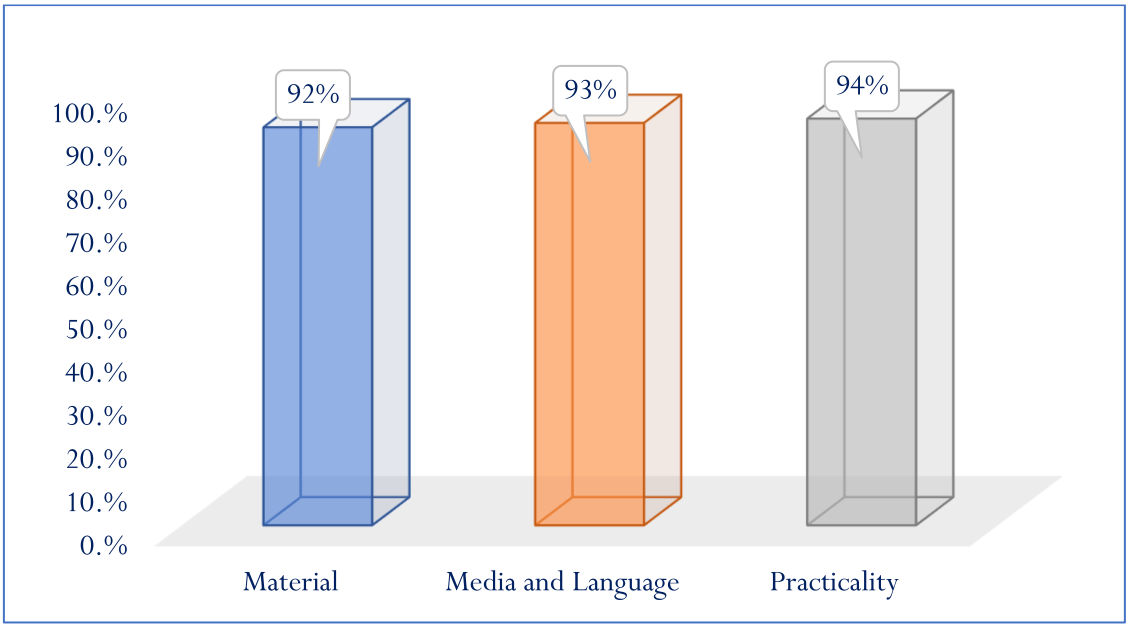

Figure 5. Chart diagram of material, media, language experts, and practicality

Figure 5 illustrates the scores across three assessed aspects: the material aspect scored 92%, the media and language aspect scored 93%, and the practicality aspect achieved 94%. These results collectively indicate that the Shielded Metal Arc Welding learning module is well-suited for classroom use, as each aspect falls within the "valid" and "very practical" categories. Consequently, this teaching module is ready for application in vocational schools. The upcoming steps will include introducing the revised module in actual classroom settings to assess its practical effectiveness and to gather further insights for potential enhancements.

4. Discussion and implication

This study developed a teaching module aligned with the FLIC curriculum for Shielded Metal Arc Welding (SMAW) material in vocational high schools to address existing instructional media limitations. Previous findings highlight that practical learning resources in vocational settings are essential to ensure graduates possess competencies relevant to advancements in science and technology (Hamid et al., 2020; Sangsawang, 2020). According to (Lim et al., 2024), self-directed learning modules provide a structure that encourages students to learn independently, assess their understanding, and explore content in greater depth.

However, prior research has also revealed that existing modules often fail to meet specific learning objectives, particularly for specialized techniques like SMAW (Prasetya et al., 2023). Several studies, such as those by (Rahim et al., 2024), indicate that gaps in these modules often require teachers to make manual adjustments, which can impact the effectiveness of knowledge transfer.

This study proposes a solution by developing a Problem-Based Learning (PBL) module to align theory with practical field applications. PBL supports independent learning and trains students to tackle real-world challenges that mirror workplace situations, thus enhancing their critical thinking skills (Wulansari & Nabawi, 2021). The integration of PBL aligns with findings from (Hendarwati et al., 2021), who state that this approach can improve student engagement and collaboration while also preparing them to meet the demands of the modern workforce. Consequently, the implications of this study contribute significantly to vocational pedagogy, demonstrating that a module customized and integrated with a PBL approach can enhance students' overall learning outcomes.

This underscores the importance of developing modules that deliver academic content and support the growth of social skills and critical thinking abilities essential for today's job demands.

5. Conclusion

This study underscores the significance of vocational education in equipping students with essential skills to meet the demands of the labor market, focusing specifically on Shielded Metal Arc Welding (SMAW) techniques. However, the existing learning modules do not meet competency requirements and lack a comprehensive content structure. This research develops a new SMAW module aligned with an FLIC curriculum, integrating Problem-Based Learning (PBL) to promote critical thinking and practical application. The findings indicate a high feasibility assessment from content and media experts, with scores of 0.924 from subject matter experts and 0.936 from media specialists and positive feedback regarding the utility and potential for student engagement. Additionally, practical usability test results reveal that this module is highly practical, achieving an average score of 94% based on subject teachers' evaluations. Overall, this research provides an innovative instructional tool that fosters independent learning and enhances understanding among vocational high school students, contributing to improved learning outcomes and better preparation for professional challenges in technical fields.

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Declarations

Author contribution

David Beckham Butar Butar: Conceptualization, Methodology, Data Curation and Writing - Original Draft. Nelvi Erizon: Supervision, Conceptualization, Methodology and Writing - Original Draft. Arwizet K and Primawati: Validation, Investigation and Writing - Review & Editing.

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Conflict of interest

The authors have no conflict of interest with any party and agree to the review and publication process of the article.

Ethical Clearance

This research has obtained permission from the Education Office of the Sumatera Barat Provincial Government with letter number 420.02/2538/PSMK-2024. The involvement of teachers and students who are the subject of this research is in accordance with the Declaration of Helsinki.

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