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Micro-Credential Program for Rooftop Solar PV Installation to Enhance Work Readiness of Vocational High School Students in Renewable Energy Engineering

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Abstract
Micro-Credential Program for Rooftop Solar PV Installation to Enhance Work Readiness of Vocational High School Students in Renewable Energy Engineering. The energy transformation towards clean energy sources has driven the rapid development of rooftop solar power plants (PLTS) in Indonesia, which has resulted in an increasing need for skilled workers in the renewable energy sector. However, graduates of Vocational High Schools (SMK) majoring in renewable energy engineering still face a competency gap with industry needs. This study aims to develop a micro-credential program for installing rooftop solar power systems and test its effectiveness in improving the job readiness of vocational high school students. Using a Research and Development (R&D) approach with the 4D model (Define, Design, Develop, Disseminate) in the pilot study phase, the study involved 20 12th-grade students of the Electrical Power Installation Engineering Vocational High School. Evaluation was conducted through a one-group pretest-posttest design reinforced by practical assessments, a self-confidence scale, and an industry acceptance survey. The results showed that the micro-credential program was successfully developed with a 40-hour curriculum structure covering aspects of occupational safety, mechanical and electrical installation, system testing, and troubleshooting. The program implementation showed a significant increase in students' technical competency with an average N-Gain of 0.71 (high category), increased self-confidence, and all participants were able to independently complete the mini solar power plant installation practice. An industry acceptance survey showed an average satisfaction level of 4.3 out of 5. The micro-credential program has proven effective in bridging the competency gap between vocational high school graduates and the needs of the renewable energy industry. Policy implications include the need to integrate micro-credential schemes into vocational high school curricula and formal recognition from industry and the government.

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1. INTRODUCTION

The transition from fossil fuels to renewable energy is global but has regional variations in progress. Denmark and Germany are two of the leaders in wind integration and China and India have annual growth rates of more than 30% for solar and wind, respectively, but the level of integration varies across the Americas [1]. At present, renewable energy accounts for almost 60% of new power-generation capacity worldwide and the International

Energy Agency expects this trend to continue until 2040. Mainly due to solar and wind technologies, which will be 40-70% less in cost for solar technology and 10-25% less in cost for wind technology [2]. Policy instruments including feed-in tariffs, renewable portfolio standards, and international obligations such as the Paris Agreement have successfully driven the uptake of renewable energy, but many gaps in implementation still exist, particularly in developing regions [3]. Smart grid technology and battery harnessing have been identified as one of the important drivers of increased reliability of grids and used to optimize utilization from a renewable energy supply perspective. Battery storage is referred to as the most critical technology for easing solar energy limitation and enhancing power quality [4]. There remain several multidimensional challenges to the transition such as, intermittency of renewable energy; initial capital intensive technologies; limitations in infrastructure and regulatory complexity; environmental effects- especially pollution from fossil fuel alternatives, and opposition at political levels, which requires continuing international cooperation to address its diverse aspects [3], [5].

With growing up renewable energy, it has become as well important for the sector to develop technical competencies requiring a workforce with specific technical competencies per job that adapt quickly as standards and industry technology evolve. Nonetheless, a long-lasting skills camp emerges between the skills and competencies of the formal vocational education graduates and what is effectively needed by the industry in renewable energy domains such as advanced solar technology, storage systems, or grid integration techniques. One of the greatest challenges for many countries to make the transition to renewables is a shortage of skilled working professionals in this very field. By 2023, global solar photovoltaic jobs are expected to reach 7.1 million, up from 4.9 million in 2022. Meanwhile, 44% of companies in the solar panel industry are struggling to find candidates with the required competencies. This is compounded by the fact that current formal education programs are ineffective in equipping students with the in-depth knowledge and practical skills needed, such as solar design, cost analysis, and grid integration, which are essential for meeting the demands of the growing solar photovoltaic job market [6]. These diversities result in a higher installation charge, delays in their coronation, and an extended-rank threat to workplace safety. This problem is even more severe in developing countries, where the TVET system continues to adhere to a conventional educational model that fails to adequately respond to ever-changing industrial requirements and new tools, including smart technologies such as AI and IoT [7]. To address this challenge, the education sector must find innovations to offer flexible, focused, and industry-aligned skill development pathways. One of the methods is to enhance collaboration between academia and industry and adopt adaptive learning frameworks that can continuously adapt to technological advancements [8].

Micro-credentials are a new educational innovation that can partially close the education-industry gap. Micro-credentials can be described as an identifiable and recordable set of small-sized knowledge and skills that scale up what formal, informal or nonformal degrees or certificates offer, establishing a focused, flexible and accessible route to career progression [9]. Micro-credentials, as opposed to traditional university degrees which require 3-4 years of study, are short-form qualifications specializing in any number of competencies that are directly linked to labor market needs. Micro-credentials are agile, flexible, and inclusive tools to improve employability, facilitate institutional innovation and encourage lifelong learning while addressing current gaps between educational outcomes and the needs of industry realities [10], [11]. Micro-credentials offer a unique mechanism in the Technical and Vocational Education and Training (TVET) system to respond to rapidly changing competency needs because their flexibility helps avoid long approval bureaucracies for curriculum adjustments required on formal qualification framework

changes resulting from technology influence. Research in a developing country context further underwrite the importance of micro-credentials to close the skills gap in higher education and vocational training systems as being quasi essential. They can also provide higher accessibility to training, due to lower costs and a broader range of options than traditional certification paths [12], [13].

Micro-credentials have become a new way to learn that has had a big effect, especially in higher education and professional training [14]. Nonetheless, deficiencies in its execution persist, especially in vocational education and technical skills, such as in renewable energy [15]. Most of the research on micro-credentials has been done in rich countries' higher education systems. This has led to problems with its usage in underdeveloped countries, especially in secondary-level Technical and Vocational Education and Training (TVET) systems [16], [17]. Furthermore, although micro-credentials are recognized for enhancing general work skills, empirical research examining their effectiveness in specific technical skills is still limited [12], [18].

The correlation between micro-credentials and green skills development, especially in the field of solar PV installation, is still a relatively new but very interesting area to be explored to improve vocational education in Indonesia [1]. Micro-credentials provide a flexible, modular, and competency-based form of skill-acquisition that fits well in rapidly evolving technical fields, such as renewable energy and is enabling learners to acquire specific competencies needed for industry jobs much faster than through traditional education pathways [12]. The Green MiCred Pathways framework emphasizes the critical importance of tailoring green skills training to specific industry needs, ensuring that content remains relevant and directly applicable, which is particularly effective in the context of solar PV installation where both technical proficiency and environmental awareness are paramount [19]. The successful implementation of such programs, however, requires careful consideration of several key elements, including industry-validated practical assessment and digital portfolio development, which serve as comprehensive and verifiable approaches to demonstrating work readiness and enhancing the credibility and recognition of micro-credentials for both learners and employers [11], [20], [21]. Furthermore, contextual factors influencing the implementation of micro-credentials in Indonesian vocational high schools including institutional readiness, curriculum alignment challenges, and industry partnership mechanisms play a critical role in program effectiveness, yet these dimensions remain empirically under-investigated, a gap that is particularly significant given the distinctive characteristics of Indonesian vocational education where students are oriented toward direct labor market entry and where robust industry partnerships are essential for ensuring the relevance and quality of skill development programs [22], [23].

Using these conditions, conducting research to develop and test the implementation of a micro-credential program for rooftop solar power systems installation is necessary for students of Vocational High Schools in Renewable Energy Engineering as a strategic effort to mitigate graduate upon graduation with timelines alignment with national energy transition agenda. The novelty of this research is the development and implementation of enterprise based practice digital portfolio model micro-credential for rooftop solar panel installation applied to high school vocational students, followed by industry feedback in the work readiness assessment. This research also extends the emerging literature on micro-credentials into vocational secondary education, which remains less well researched in the academic landscape.

The specific objectives of this research are: (1) develop a rooftop solar panel installation micro-credential program which aligned needs and characteristics with both industry and vocational high school students; (2) examine the effectives of implementation of the micro-credential program on developing technical competences of vocational high

school students based on area competency for rooftop solar panel installation; (3) analyze confidence levels and job readiness after participating in learning activities through a micro-credential roof top solar panel; and, (4) measure résumé response around acceptance from related industries.

2. RESEARCH METHODS

2.1.Research Design

This research uses a research and development (R&D) model, marked by a pilot study with the use of 4D development model (Define, Design, Develop, Disseminate) by Thiagarajan, Semmel, and Semmel [24]. This method was selected as it permits the structured design from industry needs assessment through a competency-based curriculum and limited delivery, through to preliminary effectiveness measurement. This research targeted the development of vaccine products and assessment of industrial feasibility and acceptability, not generalizability to the population [25].

The Define stage included an analysis of the rooftop solar power plant industry needs, a competency gap analysis for vocational high school graduates, and a review of basic rooftop solar power plant installation competency standards [26]. Data were obtained through literature review, focus group discussions (FGDs) with industry partners working in the solar power plant sector, and a review of the curriculum of the Electrical Power Installation Engineering Vocational High School and the competency standards issued by the National Professional Certification Agency (BNSP). The expected outcome of this stage is the formulation of core micro-credential competencies covering the knowledge, skills, and work attitudes required for basic rooftop solar installation [27].

The design phase includes the development of a micro-credential curriculum with a 40-hour learning load, the development of learning modules, the development of practical job sheets, and the development of evaluation instruments consisting of a knowledge test (pretest-posttest), a practical assessment rubric, a self-confidence scale, and an industry acceptance questionnaire. The curriculum is made up of 30% theory and 70% practice to make sure that students learn the technical skills they need [28].

The development phase includes validation of learning instruments and tools by subject matter experts, media experts, and industry practitioners; implementation of the micro-credential program to 20 partner vocational school students; and evaluation of its effectiveness through a one-group pretest-posttest design reinforced by practical assessments and industry surveys [29]. Program implementation takes place over five days (8 hours per day) in the vocational school's practical workshop, involving instructors from academia and industry practitioners. The dissemination stage includes compiling the final research report, writing scientific articles, compiling policy briefs for vocational education policymakers, and disseminating research results to other partner vocational schools and scientific forums [30].

Participants in this study consisted of 20 students of grade XII of the Renewable Energy Engineering Expertise Program at a State Vocational High School in Bekasi City [31]. Sample selection was carried out using a purposive sampling technique based on the following criteria: (1) availability of adequate PLTS practice facilities at the school, (2) willingness of the institution to partner in the pilot program, (3) relevance of the school curriculum to renewable energy competencies, and (4) students already have basic knowledge of renewable energy engineering subjects [21].

Data were collected using five types of instruments developed based on the technical competency framework and renewable energy industry standards. First, a multiple-choice knowledge test measured conceptual understanding of rooftop solar

power plants. Second, a practical observation sheet with an assessment rubric measured psychomotor skills in preparation, occupational safety (K3), mechanical/electrical installation, testing, and troubleshooting [6]. Third, a self-confidence scale measured students' perceived job readiness. Fourth, an industry acceptance questionnaire evaluated graduates' relevance to job market needs. Fifth, an interview guide collected qualitative data from students and industry practitioners. The content validity of the instruments was determined through an expert judgement process involving two subject matter experts, one media expert, and two solar power industry practitioners [32].

Data collection was conducted over five days (40 learning hours) at a partner vocational school's practical workshop [6]. The procedure began with a pretest to measure students' baseline knowledge. Next, students participated in a program intervention that included theoretical learning (30%) and hands-on practice (70%) under the guidance of academic instructors and industry practitioners. After the program concluded, students took a posttest and self-assessed practice. Industry acceptance data was collected through surveys and focus group discussions (FGDs) after industry representatives observed students' skills demonstrations and digital portfolio presentations. All procedures received ethical approval from the relevant institutions and students' consent to participate.

2.2. Data Analysis

In quantitative data analysis, descriptive statistics describe the distribution of data and inferential statistics using a paired sample t-test to measure the significance in differences between pretest and posttest scores. In analyzing improvements in student competency, the N-Gain (Normalized Gain) calculations with high, medium and low interpretation categories were carried out. At the same time, thematic analysis was used for qualitative data from interviews and observations to provide an in-depth contextual understanding of patterns crucial for interpreting quantitative results related to student learning experiences and to industry perceptions [31]. Statistical analyses were performed using appropriate statistical software.

3. RESULTS AND DISCUSSION

3.1. Results

3.1.1. Define Stage

A needs analysis conducted through literature studies, discussions with industry partners (three solar power plant service providers), and a review of vocational high school (SMK) curricula yielded important findings regarding the competency gap between vocational high school graduates and industry needs. The industry partners identified that the most needed technical competencies for entry-level workers in the rooftop solar power plant sector include (1) the ability to read technical drawings for solar power plant systems; (2) skills in mechanical installation of solar panels (mounting structures); (3) electrical installation skills (wiring, inverters, and protection); (4) system testing and commissioning skills; and (5) an understanding of occupational safety (K3) at heights and electricity.

A review of the curriculum of the Electrical Power Installation Engineering Vocational High School (SMK) shows that basic competencies for solar power plants are covered in the fundamentals of renewable energy engineering courses, but the depth of practical application remains limited. Learning focuses more on theory and basic laboratory practice, not including actual field installations. Meanwhile, the competency standards issued by the National Agency for Standardization (BNSP) for solar power plants are still oriented toward the technician level, which requires work experience, making them less accessible to recent vocational high school graduates.

Based on this analysis, the core competencies of the basic level rooftop solar power installation micro-credential program were formulated, which include 5 competency units: (1) implementing occupational health and safety (K3) procedures for rooftop solar power installation; (2) installing solar panel mounting structures; (3) installing solar panels, inverters, and electrical components; (4) testing and commissioning rooftop solar power systems; and (5) troubleshooting and performing basic maintenance of rooftop solar power systems.

3.1.2. Design Stage

Based on the formulation of core competencies, a micro-credential curriculum has been developed with a total workload of 40 hours of learning, consisting of:

Table 1. Curriculum Structure of the PLTS Atap Micro-Credential Program

Module	Title	Theory (Hours)	Practice (Hours)	Total (Hours)
1	Occupational Safety for PV Installation	3	3	6
2	Solar Panel Mounting Structure Installation	2	6	8
3	Solar Panel, Inverter, and Electrical Components Installation	3	8	11
4	System Testing and Commissioning	2	6	8
5	Basic Troubleshooting and Maintenance	2	5	7
Total		**12**	**28**	**40**

In addition to the curriculum, at this stage, learning modules for each module, practical job sheets containing step-by-step implementation guidelines, practical assessment rubrics, knowledge test questions (pretest-posttest), confidence scales, and industry acceptance questionnaires are also being developed.

3.1.3. Develop Stage

Expert validation of the learning tools and research instruments was conducted by two subject matter experts (lecturers in electrical power engineering), one media expert (lecturer in learning media), and two industry practitioners (technical managers from solar power plants). The validation results indicated that the learning tools were deemed feasible with minor revisions, with an average score of 4.2 on a scale of 5. Revisions included refining the illustrations in the modules, adding occupational safety aspects to each job sheet, and adjusting the assessment rubric for greater operational efficiency.

The program was implemented over five days (Monday-Friday) from 8:00 AM to 4:00 PM WIB (Western Indonesian Time) at the partner vocational school's practical workshop. Participants were 20 12th-grade students majoring in Solar, Hydro, and Wind Energy Engineering who had completed the fundamentals of renewable energy engineering. The instructors consisted of two lecturers from the research team and one practitioner from the industry partner. Learning was conducted using a hands-on approach, with each participant having the opportunity to practice directly under the guidance of an instructor. The instructor to participant ratio was 1:7, allowing for intensive support during the practical sessions.

3.1.4. Result of Implementation Micro-Credential Programs

Pretest and posttest data showed a students' technical competency after participating in the micro-credential program. The average pretest score was 58.6 (SD = 6.8), and the average posttest score increased to 85.3 (SD = 5.2). A paired-sample t-

test showed a statistically significant difference ($t = 18.47$; $p < 0.001$), indicating that the micro-credential program was effective in improving students' theoretical knowledge of rooftop solar installation.

N-Gain (normalized gain) analysis showed an average increase of 0.71 (SD = 0.12), which is considered high. Sixteen students (80%) were in the high gain category (N-Gain ≥ 0.7) and four students (20%) were in the moderate gain category (0.3 ≤ N-Gain < 0.7). No students were in the low gain category, indicating that the micro-credential program provided equitable competency gains across all participants. The complete pre-post comparison is shown in Table 2.

Table 2. *Pretest and Posttest Scores and N-Gain Analysis*

Parameter	Pretest	Posttest	Improvement	*N-Gain*	Category
Minimum Score	45	75	30	-	-
Maximum Score	70	95	25	-	-
Mean	58.6	85.3	26.7	0.71	High
Standard Deviation	6.8	5.2	-	0.12	-

Practical assessment using a six-criteria rubric demonstrated that all 20 participants (100%) successfully completed the mini PV installation task independently with a minimum score of 78. The mean practical score was 86.4 (SD = 4.8). The distribution of grades was as follows: 5 students (25%) achieved an A (≥ 90), 12 students (60%) achieved a B (80-89), and 3 students (15%) achieved a C (75-79). The highest-scoring aspect was mechanical installation (M = 89.2) and the lowest-scoring aspect was troubleshooting (M = 81.5).

Self-confidence scores were measured before and after the program. The average self-confidence score increased from 3.2 (on a scale of 1-5) at the beginning of the program to 4.3 at the end. The highest increase was in the item "I am confident I can install rooftop solar panels myself" (from 2.8 to 4.4) and the lowest in the item "I am ready to work in a solar panel company after graduation" (from 3.4 to 4.1), which still indicated some doubt despite the significant improvement.

Interviews with participants revealed that the micro-credential program provided hands-on experience that built their confidence. One participant stated: "Previously, I only knew the theory from books, but now I actually experience installing solar panels on a rooftop. This makes me more confident in applying for jobs in this field." Another participant added: "Industry instructors provided practical tips that weren't covered in books, so we were better prepared for real-world situations."

3.1.5. Industry Acceptance

An industry acceptance survey was conducted with five representatives from three industry partners who observed students' portfolio presentations and skills demonstrations at the end of the program. The survey results showed an average satisfaction level of 4.3 on a scale of 5, with the following ratings: (1) relevance of competencies to industry needs: 4.4; (2) quality of students' technical skills: 4.2; (3) understanding of occupational safety: 4.5; (4) work attitude and professionalism: 4.3; and (5) readiness for field placement: 4.1.

Focus group discussions with industry representatives expressed appreciation for the micro-credential program. A technical manager from a solar power plant company stated: "This program is excellent because it immediately equips students with the skills we need. Normally, we have to retrain new employees for 1-2 months, but graduates of this program can be hired immediately with minimal training." Another industry

representative added that the micro-credential program could serve as a model for reducing recruitment and training costs for new employees.

However, industry representatives also noted the need to strengthen aspects of troubleshooting and adapting to various equipment brands, given the practice during the program using specific brands of equipment. The industry suggested that future micro-credential programs could include an introduction to various brands of inverters and solar panels commonly used in the market.

3.2.Discussion

3.2.1. Alignment of Micro-Credential Programs with Industry Needs

The research results show that the developed micro-credential program aligns with the needs of the rooftop solar power industry, as reflected in expert validation and industry acceptance surveys. These findings align with the concept of micro-credentialing as an approach to competency development oriented toward labor market needs [12]. Industry involvement from the define stage (needs analysis) to the develop stage (implementation) ensures that the competencies developed are truly relevant to field practices.

The flexible and modular characteristics of micro-credentials allow for quick curriculum adjustments to keep pace with the development of PV technology. In the context of vocational schools, where regular curriculum changes require a lengthy process and involve many stakeholders, micro-credentials offer an alternative to respond to the rapidly evolving needs for new competencies [13]. This is highly relevant to the renewable energy sector, where technology is continuously evolving, such as innovations in solar panel efficiency, energy storage systems, and smart inverter technology.

The composition of 30% theory and 70% practice in the micro-credential program reflects an effective experiential learning approach for vocational education. McGreal and Olcott [21] emphasize that effective vocational learning must provide hands-on experience in contexts that closely resemble real work situations [21]. The practice job sheet developed with step-by-step guidance helps students master technical procedures systematically, while hands-on practice with actual equipment builds the psychomotor skills needed in the field.

3.2.2. Effectiveness in Improving Technical Competence

The increase in students' technical competency, with a high N-Gain (0.71), demonstrates the effectiveness of micro-credential programs in transferring technical knowledge and skills. This finding aligns with research by Hanshaw [16], which found that micro-credentials effectively strengthen the employability skills of higher education graduates [16]. In the vocational high school context, greater effectiveness is possible because participants already have a foundation of knowledge from regular learning, allowing the micro-credential program to reinforce and deepen specific competencies.

A learning design that integrates theory and practice simultaneously (rather than separately) contributes to the program's effectiveness. Each module is structured according to a pattern: a brief theoretical explanation, an instructor demonstration, guided practice, and independent practice. This pattern allows students to build conceptual understanding while developing procedural skills in an integrated manner. Al-Greer et al. [6] emphasized the importance of project-based learning for developing applicable technical competencies in their research on solar power plant (PLTS) implementation in vocational high schools [6].

The success of all participants in independently completing a mini solar power plant (PLTS) installation practice demonstrates that the micro-credential program is

able to build student independence in carrying out technical tasks. This is important because job readiness is measured not only by knowledge and skills but also by independence and confidence in carrying out tasks without intensive guidance. Malik et al. [13] discovered that employers highly regard graduates who exhibit independence and problem-solving abilities, which intensive, hands-on learning can cultivate [13].

3.2.3. Impact on Job Readiness

Increased student confidence and positive industry reviews indicate that micro-credential programs have a positive impact on graduates' job readiness. Job readiness is a multidimensional construct encompassing not only technical competencies but also personal attributes such as self-confidence, communication skills, and an understanding of work culture [7]. Micro-credential programs that involve intensive interaction with industry practitioners and simulated real-world work situations help develop these non-technical aspects.

The involvement of industry instructors provides significant added value. Students not only learn technical skills but also understand industry work quality standards, professional ethics, and actual safety practices. Miao et al. [33] found in their research in the urban renewable energy sector that micro-credentials facilitated by industry practitioners were more effective in preparing the workforce than training solely facilitated by academics [33]. An industry acceptance survey, with an average score of 4.3, indicates that micro-credential programs produce graduates who meet industry expectations. This finding is important because industry acceptance is a valid indicator of job readiness. In an ideal vocational education ecosystem, curricula and training programs should be designed based on industry needs and evaluated based on industry satisfaction with graduates. Micro-credential programs that engage industry from inception through evaluation ensure this alignment.

3.2.4. Policy and Practice Implications

The findings of this study have important implications for vocational education policy in Indonesia, namely the need for formal recognition of micro-credential schemes within the national education system to ensure they have equivalent exchange value to diplomas and professional certificates in the labor market, as recommended by UNESCO through an inclusive qualifications framework. Furthermore, micro-credential programs need to be integrated into vocational high school (SMK) curricula as enrichment or cross-interest programs through collaborations between schools and industry and universities tailored to local economic potential. The development model, which involves industry from needs analysis to evaluation, should also be replicated for other areas of expertise, with the support of government incentives to ensure the relevance of graduates. Finally, strengthening digital portfolios as proof of competency needs to be encouraged, as employers increasingly rely on project documentation and skill demonstrations in recruitment processes [22].

3.2.5. Research Limitations

This study has several limitations that need to be considered in interpreting the results, including (1) the use of a one-group pretest-posttest design without a control group, which limits the causal attribution of competency improvement entirely to the micro-credential program, so that further research with an experimental design is needed; (2) the limitation of subjects to 20 students from one vocational school, which limits the generalizability of the findings, so that replication across various schools with diverse characteristics is needed; (3) the measurement of work readiness is still limited to technical competencies, self-confidence, and industry acceptance and does not include objective indicators such as speed of getting a job or performance in the workplace, so that a longitudinal study is needed to test the long-term impact; and (4)

the scope of the program is only at the basic level with a duration of 40 hours, so that the development of advanced programs with more complex competencies is needed to support long-term career development.

4. CONCLUSION

This study concludes that the developed micro-credential program for rooftop PV installation is effective in enhancing students' technical competencies and bridging the competency gap between vocational school graduates and the renewable energy industry. The results confirm that the program's flexible, modular, and hands-on design significantly improves both knowledge and practical skills (with a mean N-Gain of 0.71 and 100% successful completion of mini-PV installation), highlighting the critical role of industry engagement throughout program development and implementation in ensuring relevance, quality, and graduate readiness for field deployment with minimal additional training.

Recommendation

In light of the findings, it is suggested that policymakers and educators target formal recognition for micro-credential schemes in the national education framework; incorporate these programs into SMK as enrichment programs at the schools; extend this industry collaboration approach to other vocational priority fields; and enhance digital portfolio development (for showcasing competencies). Research is needed to examine the impact of micro-credential programs on job market outcomes over time for graduates, as well as how this model of change applies to various contexts both nationally and internationally, taking into account formal qualification equivalencies and recognition across institutions.

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