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Dick & Carey's Analyze Learners and Contexts Stage for Vocational School Learning Model Development

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ABSTRACT

The development of vocational learning models should be dynamic, responsive to socio-technological changes, and rooted in a deep understanding of the learner profile. The purpose of learner analysis is to design instruction that matches the needs, abilities and preferences of learners. This research uses Dick & Carey's Instructional Design Research & Development (R&D). This research outlines the initial steps of Dick & Carey in the third stage, namely Analyze Learners and Contexts. The research instrument used interview, questionnaire and observation techniques. Welding vocational education faces major obstacles in the form of inadequate facilities, such as non-ideal student-machine ratios, outdated equipment, and lack of supporting technology such as Virtual Reality (VR) welding simulators. Strengthening partnerships with industry through more inclusive internship programs and providing high standard infrastructure are crucial steps to produce graduates who are competent and ready to compete in the industrial era 4.0.

Keywords: Dick & Carey's, Vocational School, Learners, Learning Model Development

INTRODUCTION

The analysis of *learners* and *contexts* in the Dick & Carey model aims to understand the characteristics of learners and the environment in which learning and application of skills takes place (Walter Dick. Lou Carey, 2015). Learner analysis according to (Chaw & Tang, 2023) focuses on identifying attributes such as prior knowledge level, ability, motivation, learning style, cultural background, as well as potential barriers (e.g. physical limitations or technology access).

The purpose of learner analysis is to design instruction that suits learners' needs, abilities and preferences. For example, if learners have limited internet access, the learning design will avoid reliance on *online* content. Understanding characteristics, learning design can avoid inappropriate assumptions, ensure material is not too difficult or too basic, and choose teaching strategies that maximize engagement (Moleko, 2021).

Context analysis according to (Walter Dick. Lou Carey, 2015) focuses on two aspects: the learning context (the environment in which learning occurs) and the performance context (the environment in which skills will be applied). This analysis includes an evaluation of available resources (such as technological tools, physical space, or time), institutional policies, social support, as well as environmental barriers (e.g. noise or lack of facilities).

The purpose of evaluation is to ensure that the instructional design is realistic and can be implemented in real conditions (Kumar et al., 2018). For example, if welding skills are taught in a workshop without adequate ventilation, instructions should include additional safety procedures. Learner and context analysis according to the

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Dick & Carey model will create learning that is not only personally relevant but also practical in real-world situations, thereby increasing the success of knowledge and skills transfer.

Project-based learning is more suitable for students with kinesthetic learning styles, while the use of digital media is needed to increase motivation (Andriana, 2021). In addition, the context of Industry 4.0 demands the integration of skills such as computational thinking and technological adaptation in learning models, which must be adjusted to the readiness of school infrastructure and teacher competencies (Putra, 2024). Thus, student and context analysis become the foundation to ensure the relevance of the learning model to real needs.

The main challenge in linking student-context analysis with learning model development lies in the social and technical dynamics. Studies in vocational schools reveal that social stigma towards vocational education often influences students' perceptions, necessitating approaches such as deep learning or game-based learning to increase engagement (Dahalan et al., 2024). The context analysis identified the need for multidisciplinary collaboration, such as involving industry in the development of teaching materials and using student performance data to update learning methods (Marta et al., 2024).

The research recommends alean learning approach to simplify the curriculum based on industry skill prioritization,skill-based assessment monitor student progress in real-time (Slaton et al., 2024). The school-based enterprise model in schools that develop production units is a concrete example of how local context can be integrated into learning (Iskandar & Sudira, 2019). The development of vocational learning models should be dynamic, responsive to socio-technological changes, and rooted in a deep understanding of the student profile and the supporting ecosystem.

LITERATURE REVIEW

Vocational schools in the last decade have undergone a significant transformation, especially in integrating competency-based curriculum and industry needs. Research by (Yoto et al., 2024) emphasized the importance of evaluating the *teaching factory* model using the CIPP (Context, Input, Process, Product) approach to improve the skills of vocational students, showing that collaboration with industry increases the relevance of learning. Similar study by (Wahjusaputri et al., 2024) developed a*hybrid teaching factory*model that combines school governance with industrial practice, resulting in increased*employability skills of*vocational students. This approach is in line with the demands of the digital era that requires rapid adaptation to changes in technology and the job market.

On the other hand, technology integration in vocational learning is a major focus. *Virtual Reality* (VR) in heavy equipment engineering learning improves students' conceptual understanding and practical skills (Tsauri et al., 2024). Research (Suhanto et al., 2024) also proved that the application of*problem*-based learning(PBL) with mockup media improves student competence in programmable logic control. Challenges such as technological infrastructure gaps and teacher readiness in adopting digital tools are still an obstacle (Prasetyono et al., 2024).

Vocational school prospects are also supported by strengthening entrepreneurship and multi-sector partnerships. Learning motivation and creativity have a significant effect on the entrepreneurial intentions of fisheries students, which can be developed through local potential-based learning (Priyono et al., 2024). Evaluation of the apprenticeship program by (Suhartanta et al., 2024) confirmed that sustainable cooperation between vocational institutions and industry improves student competencies and supports the sustainability of education programs. However, a systematic strategy is needed to ensure curriculum alignment with industry dynamics, especially in the context of the industrial revolution 4.0 and society 5.0.

Students in vocational schools face demands to master technical skills that are aligned with the dynamics of modern industry. The integration of digital skillsin the vocational curriculum is crucial in preparing graduates for the industrial revolution 4.0 and Society 5.0 (Ubihatun et al., 2024). For example, project-based learning through social media or digital game-based learning improves students' computational thinking and adaptation to new technologies (Shafarin et al., 2025). The main challenge lies in the gap between student capacity and industrial needs in developing countries, where education infrastructure is often inadequate (Avana et al., 2024). Policy analysis reveals that lack of coordination between vocational schools, and the world of work hinders the effectiveness of training (Terentyeva et al., 2018).

The context of vocational schools is influenced by structural factors such as government policies, teacher quality, and public perception. The study confirms that the social stigma against vocational education is still strong, with many parents and students considering it as an alternative path to academic education (Malkus, 2019). On the other hand, curriculum transformation that adopts a lean learning or deep learning approach is beginning to be implemented to improve the efficiency and personalization of learning, especially for students who are inclusive or who have special needs (Gofur1 et al., 2023). Implementation is often hampered by budget constraints and lack of teacher training in current methodologies (Fauzal Syarif et al., 2024). Holistic policies, such as incentives for industries that collaborate with schools, are considered to be able to strengthen the vocational ecosystem(Watters et al., 2016).

The future prospects of vocational schools depend on adaptability to technological and social changes. Innovations such as skill-based learning to prepare superior human resources towards a Golden Indonesia 2045 are examples of strategic efforts (Soesatyo, 2023). In addition, the application of digital game-based learning increases student motivation and strengthens understanding of technical concepts through interactive simulations (Anastasiadis et al., 2018). This success must be supported by flexible regulatory updates and increased access to digital resources (KewalRamani et al., 2018). Thus, synergy between policy, pedagogical innovation, and industrial-academic collaboration is key in shaping a responsive and sustainable vocational school context (Bikard et al., 2019).

The vocational school learning model is designed to blend the practical needs of the industry with a holistic approach to education. The vocational learning process should be interactive, holistic, and student-centered learning, with an emphasis on collaboration and contextuality (Permendikbud, 2022). Some of the commonly applied models include the Company model, School-based model, Cooperative model and School-based enterprise (Xu, 2019).

The cooperative model or Dual System Education is considered the most effective because it combines theoretical learning in the classroom with hands-on experience in the industry, increasing students' job readiness (Muhambetaliev, 2016). Model implementation is often hampered by a lack of coordination between schools and industry, especially in resource-constrained areas (Irwanto, 2020a).

Technology integration is the key to the transformation of vocational learning models in the era of the industrial revolution 4.0 and Society 5.0. Project-based learning by utilizing artificial intelligence (AI) and *the Internet of Things (IoT)* has begun to be implemented to improve *students' computational thinking* skills and adaptation to industrial dynamics (Irwanto, 2020b). Digital game-based learning is used to simulate real work situations, while skill-based learning curricula are focused on mastering technical skills such as robotics and data analysis (Rathod, 2023).

The sustainability of the vocational learning model depends on curriculum adaptation and multidisciplinary collaboration. The 4Cs (Critical Thinking, Creativity, Collaboration, Communication) approach is considered relevant to form competitive graduates, with a curriculum that is constantly updated according to industry developments (Iskandar & Sudira, 2019). The school-based enterprise model also shows success in integrating local potential into learning, such as the development of production units that adapt to regional economic needs (Crentsil et al., 2023). On the other hand, efforts to overcome the social stigma against vocational education require public campaigns and incentives for participating industries(Irwanto, 2020a).

METHODOLOGY

This research uses Dick & Carey's Research & Development (R&D) Instructional Design. Development research is a research method that combines elements of research and development to produce a specific product, then test the effectiveness of the product (Sugiyono, 2022). Research and development in the context of instructional design as a systematic process to develop learning products (such as modules, curricula, or learning media) through the stages of needs analysis, design, development, formative and summative evaluation, and continuous revision (Walter Dick. Lou Carey, 2015).

Dick & Carey's Instructional Design consists of 10 steps to the development process of a product. This study outlines Dick & Carey's initial steps in the third stage, namely Analyze Learners and Contexts. The research instrument used interview, questionnaire and observation techniques. Interviews took place with 4 expertise teachers and 16 students. Teachers come from 2 people and 8 students each at the two target schools.

The analysis took place in vocational school students at Vocational High School (SMK) Negeri 6 Palu and SMK Negeri 3 Palu, Central Sulawesi, Indonesia. The focus of the research is on the Welding Engineering and Metal Fabrication expertise program, the competence of welding engineering expertise. The research was in 2 classes, 1 class each at SMK Negeri 6 Palu and 1 class at SMK Negeri 3 Palu. The total number of students involved is 61 people with details of 28 at SMK Negeri 6 Palu and 23 at SMK Negeri 3 Palu.

The development design involves two experts with doctoral education capability, 3 students in the one-to-one phase, 5 students in the small group phase. The first expert came from a lecturer in educational technology at the State University of Surabaya specializing in design and content. The second expert from the Lecturer of Mechanical Engineering at Tadulako University specializes in the content of welding engineering. Five students with the criteria for completing the learning material related to the design and content of the development objectives.

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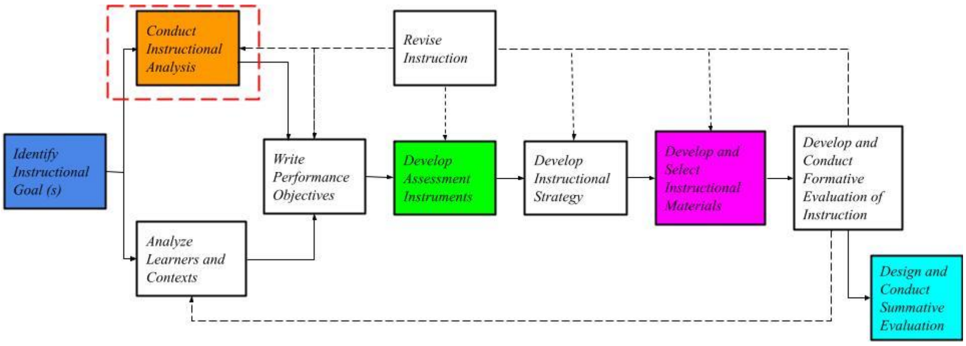

Figure 1. Dick & Carey Model R&D Stages

The orange dotted line boundary is a research step in preparation for model development. This study focuses on describing the steps of conduct instructional analysis. This aims to elaborate on the research aspect, so that it has not yet elaborated on the development aspect. As Dick & Carey's research and development consists of a research step and a development step.

RESULTS

Table 1. Description of Characteristics of Welding Engineering Expertise Program Students

Information Category	Characteristics	Data Source
Entry Skill	Familiar with and able to use welding helmets, leather gloves, aprons, and safety shoes. Understanding the importance of protective eyewear and flame-resistant clothing. Knowing how to avoid electric shocks, exposure to hazardous gases, and sparks Understand the location of fire extinguishers and emergency evacuation procedures. Understanding the types of welding machines (SMAW, GMAW) and their functions. Understanding the basic components of a welding machine (cable, torch, gas regulator). Distinguish between types of metals (carbon steel, stainless steel) and electrodes (e.g., E6013, ER70S-6). Understanding the relationship between material and welding parameters (current, voltage). Reading a ruler, caliper, and material thickness gauge Basic experience with SMAW (Shielded Metal Arc Welding) in 10th grade, such as: Making a flat position weld (1G/1F). Cleaning slag and inspecting simple welds. The ability to move the torch or electrode steadily. Calculating welding speed, gas volume, and unit conversion (mm to inches). Understanding angles and the geometry of connections. Interpreting welding symbols (e.g., position symbols 1F, 2F, 3F). Follow the instructions from the simple work drawing. Follow the teacher's instructions and work procedures. Paying attention to detail in preparing materials and tools. Working in groups for a practical project. Communicate effectively when sharing tools or workspace. Able to stand or squat for a long-time during practice. Adapting to the hot and noisy workshop environment.	K3 Guidelines (Occupational Safety and Health) Merdeka Curriculum Structure Basic Mathematics Competency Competency in reading technical drawings

		Soft skills
Prior knowledge of topic area	Understanding the principles of Shielded Metal Arc Welding (SMAW), including electrode selection and arc initiation. Familiar with common welding terms (e.g., arc, slag, penetration). Understanding base metals (mild steel, stainless steel) and their properties. Knowledge about material preparation (cleaning surfaces, removing rust/oil). Basic awareness of electrical circuits in welding machines (e.g., grounding, type of current). Experience with SMAW in flat position (1G/1F) for simple joints (butt, lap, fillet). The ability to light and maintain a bow. Safe operation of hand grinders, welding hammers, and wire brushes for post-welding cleaning. Basic measurement skills using a ruler and caliper. Cutting and grinding material to prepare joints (e.g., making a chamfer for groove welding). The use of welding helmets, gloves, aprons, and protective goggles. Awareness of fire hazards, the need for ventilation, and the risk of electric shock Basic first aid for burns or minor injuries. Safe disposal of welding waste (e.g., used electrodes, slag). Basic interpretation of welding symbols (e.g., fillet weld symbol, arrow side notation). Understanding simple technical drawings for welding projects. Experience collaborating on group projects (e.g., assembling small welding structures). Compliance with instructions, time management, and attention to detail.	Basic knowledge Practical knowledge Safety protocol Technical drawings and symbols Soft skills
Attitudes toward potential delivery system	Students tend to be enthusiastic about learning welding practice because of its concrete and practical nature. Students enjoy using welding tools, machines, and real materials, which provide immediate satisfaction when they successfully complete a welding project (e.g., making a neat 1F joint). Students who choose this major generally have clear career goals (e.g., becoming a professional welder in the oil and gas, construction, or manufacturing industries). Students view learning content (such as GMAW techniques, interpretation of welding symbols) as direct preparation for work, thus they are motivated to master it. Welding skills are considered a highly valued specialized expertise in society. Students feel proud when they are able to produce high-quality welding results, especially when compared to their peers. Students tend to be less interested in theoretical material (e.g., welding physics principles, ISO/AWS standards) if it is delivered monotonously. Interest increases when theory is linked to real case examples (e.g., analysis of accidents due to welding procedure errors). Welding requires physical endurance (standing for long periods, exposure to heat, noise). Some students consider	Positive attitude Neutral/contextual attitude Negative Attitude

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	this a natural part of the profession, while others feel tired or uncomfortable. Students feel overwhelmed when facing difficult welding positions (3F/vertical) or complex machine parameters (current, voltage, shielding gas). These difficulties can lower confidence, especially if practice facilities are limited. Some students feel that the social stigma against vocational schools (considered the "second choice" after high school) affects their motivation. Students are less motivated if their surroundings do not value technical professions like welding. Students feel that the learning content is outdated compared to industry needs in schools with limited, old equipment and minimal modern simulators. An inspiring teacher with industry experience can increase student interest through success stories or demonstrations of advanced techniques. Internship programs or visits to professional welding factories/workshops help students see the relevance of learning content to the working world, thereby improving their positive attitude. Students who often win welding competitions (such as LKS/Student Competency Competitions) tend to be more confident and enthusiastic.	Another factor
Motivation for instruction/ARCS	Start the lesson with a spectacular demonstration by welding structural components or metal art and a short video about welding applications in large industries (ships, bridges). Combining theory with hands-on practice through digital simulations and group discussions. Watching the VR welding simulator tool to practice techniques without physical risk. Assigning small projects such as designing simple products (mobile whiteboard) that require 1F, 2F, and 3F techniques.	Attention (Attracting Attention)
	Students are invited to observe the welding process at a local workshop or through a virtual visit to a manufacturing plant. Explaining how GMAW skills are used in the oil and gas, construction, or automotive industries in Indonesia. Inviting successful alumni who are professional welders to share their experiences. Give tasks that mimic real work, such as repairing school equipment or making components for community projects. Adjust the assessment criteria to align with competency certification, referring to BNSP and AWS standards.	Relevance (Relevance to Student Life)
	Students are asked to weld components for the public facility rehabilitation project in the surrounding area (mosque, village office). Start from the easiest position (1F) to the hardest (3F), with repeated practice for each position. Detailed evaluation after practice, highlighting successes and areas for improvement.	Confidence (Building Self-Confidence)
	Checklist quality criteria of welder that related to weld width, penetration, and cleanliness so that students understand the expectations. More skilled students become mentors for their struggling peers. Students receive the "Welding Expert 1F" certificate after passing the practical exam, as a form of recognition of their initial skills.	Satisfaction (Satisfaction with Learning Outcomes)

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	Organizing a school exhibition to showcase students' welding results to parents, teachers, or industry representatives. Organizing a welding skills competition between classes with symbolic prizes (welding equipment, certificates). Students create a portfolio of practice documentation and write reflections on their development. Announcement of students with the best results on the school bulletin board or social media. Students who successfully create a flawless 3F connection are invited to intern at the school's partner workshop.	
Educational and ability levels	Students learn the principles of SMAW, GMAW, Tungsten Inert Gas (TIG) welding, metallurgy (metal properties, heat treatment), technical drawing interpretation, and safety protocols. Direct practice with welding equipment, focusing on basic techniques in 10th grade (e.g., flat position welding) and progressing to complex positions (horizontal, vertical, overhead) and advanced processes (e.g., Gas Metal Arc Welding) in 11th grade. National competency test that requires students to demonstrate theoretical knowledge (written test) and practical skills (welding project). Graduation provides certification as a ready-to-work professional. The curriculum aligns with the Indonesian National Work Competency Standards (SKKNI) and includes international certifications such as AWS in schools with adequate facilities. Many schools partner with local industries (e.g., shipyards, construction) to provide real-world experience, enhance understanding of workplace safety, quality control, and workflow. Ability to operate and troubleshoot welding machines, adjust parameters (current, voltage, gas flow), and select appropriate electrodes/filler materials. Mastery of various welding processes (SMAW, GMAW) and positions (1G–4G for groove welds; 1F–4F for fillet welds). Visual inspection skills, identifying defects (porosity, undercut), and using the basics of non-destructive testing (NDT). Interpreting welding symbols, dimensions, and specifications from technical drawings. Handling challenges such as material distortion, uneven penetration, or equipment damage. Strict adherence to the use of PPE, hazard mitigation, and emergency protocols. Collaboration in group projects (e.g., fabrication of structural components) and communication with supervisors/colleagues.	Level of education (Curriculum structure, certification, internship) Level of ability (Technical, cognitive, and soft skills)
General learning preferences	Students tend to be more interested in learning that involves hands-on practice, such as using welding machines, metal joint simulations, and real projects. Students are more motivated when they can see the direct results of their work (for example, making strong and neat welds). Activities in the welding workshop are prioritized because they allow students to master basic to advanced techniques (e.g., SMAW, GMAW) through repetition and direct feedback from the teacher. Preference for a learning system that emphasizes the achievement of specific competencies (for example, mastering welding positions 1G, 2G, 3G, or welding	Practical learning Competency-based learning

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	certification according to BNSP/AWS standards). Students want to feel ready to work after graduation. Students prefer assessments through practical tests rather than written exams, because this reflects the real skills needed in the industry. Although welding is often an individual task, students enjoy group projects that involve designing metal structures or solving technical problems together. This collaboration helps students develop soft skills such as communication and teamwork. The presence of experienced instructors or industry professionals is an added value, as students can learn from real case studies and practical tips. At schools with adequate facilities, students are interested in using technology such as VR (Virtual Reality) welding simulations or software to analyze weld quality. This tool helps reduce the risk of errors during physical practice. Preference for the use of modern welding machines (e.g., MIG/MAG, TIG) and supporting tools such as plasma cutters, especially in urban schools connected to industry. Students value internship opportunities at welding workshops, factories, or construction projects. This experience reinforces understanding of industry standards and job demands. Learning linked to actual industry challenges (for example, fixing welding defects on automotive components) increases motivation and the relevance of the material. Students enjoy the opportunity to experiment with different welding techniques under the supervision of an instructor. This flexibility allows them to explore specific interests (for example, metal art or precision welding). Preference for open access to tools, materials, and practical guides during free time at school. Students appreciate intensive safety training, such as the use of PPE (Personal Protective Equipment), fire handling, and emergency procedures. This material is considered crucial for job readiness. Learning about professional responsibilities (e.g., punctuality, honesty in welding inspections) becomes an implicit preference, especially in schools partnered with industry. Students tend to rely more on traditional methods (for example, manual arc welding practice) and learning from instructors who are creative in utilizing local materials in schools with limited facilities. Collaboration with local welding shops or community projects becomes an alternative to address equipment limitations. Students appreciate theories presented contextually, such as explanations about the properties of metals or the principles of heat transfer during welding, especially when linked to visual/video examples.	Collaborative learning Integration of technology and modern tools Industry and contextual relevance Flexibility and learning autonomy Safety and work ethics Limited resources and facilities Combination of theory and practice
Attitudes toward training organization	Students generally appreciate Collaboration with local welding workshops or community projects becomes an alternative to address equipment limitations. The school focuses on hands-on learning in the welding workshop, because it provides the real-world experience needed in the workforce. Facilities such as SMAW/GMAW welding machines, personal protective equipment (PPE), and practice materials are considered important investments for skill development. Schools that partner with industry (e.g., internship projects, factory visits) receive high appreciation. Students	Positive Attitude

	feel that training is more relevant when it is directly connected to the needs of the job market. Instructors with an industry background and the ability to clearly transfer knowledge are respected by students. Students feel more confident when taught by practitioners who understand the real challenges in the field.	Neutral stance
	Students tend to be less satisfied and feel that the training is not optimal at schools with limited or outdated equipment (e.g., broken conventional welding machines, incomplete PPE). Some students feel that the curriculum has not fully adopted the latest technologies (e.g., welding robotics, digital simulations), making them less prepared to face the demands of Industry 4.0. Not all students get the opportunity to intern at renowned companies, especially in areas with limited industrial networks. This creates a sense of unfairness for some students. packed or inflexible training schedule (e.g., welding practice only at certain times) can make students feel exhausted, especially if they have to take turns using the equipment. Schools that do not provide intensive OHS training (e.g., fire handling, emergency procedures) are considered to neglect a crucial aspect. Students feel unprepared to face risks in a real work environment.	Negative Attitude
	Unclear or subjective assessment criteria (e.g., practical grades based solely on "instructor's decision") lead to dissatisfaction and distrust in the organizational system. Schools that do not provide intensive K3 training (e.g., fire handling, emergency procedures) are considered to neglect crucial aspects. Students feel unprepared to face risks in a real work environment. modern equipment (CNC plasma cutter, MIG/MAG welding machine) and complete PPE tend to receive positive responses. Example, students at the Vocational School of Excellence (SMK PK) are more satisfied because the facilities are adequate. Schools that invite industry practitioners as guest lecturers or align their curriculum with BNSP/AWS standards are considered more professional and trustworthy. An open feedback mechanism (e.g., student satisfaction surveys) enhances students' sense of ownership over the training process.	Factors that influence attitudes
General group characteristics	Students come from diverse academic backgrounds, with varying abilities in mathematics, physics, English, and technical drawing. Some students have basic practical experience (e.g. helping their parents in the workshop), while others are complete beginners. Mostly they choose this major because of their interest in the engineering field, but some also enter due to family pressure or a lack of other major options. The welding engineering class is dominated by male students (95%+), although some schools are beginning to accept female students. Female students who enroll tend to have a high motivation to challenge gender stereotypes. Students come from families with diverse economic conditions, ranging from working-class families to middle-class families. Some students work part-time at welding workshops, as construction laborers, and transporting mining materials to help cover school expenses.	Heterogeneity

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	Some students are already familiar with simple welding tools (e.g., SMAW), while others are just getting to know GMAW/MIG.	
	The class size is generally adjusted according to the workshop capacity and the availability of welding machines.	Size
	The capacity of one class is 32 students, causing a queue for using equipment at the school with limited facilities.	
	The ideal ratio is 4–5 students per machine for effective practice in a school with 5 welding machines.	
	The ratio can reach 10 students per machine, reducing individual practice time in remote areas.	Overall Impressions
	Students tend to be more enthusiastic during practical sessions in the workshop than in theory classes.	
	Students enjoy technical challenges such as mastering the vertical welding position (3F) or overcoming welding defects.	
	There was close cooperation in the group project and healthy competition to produce the best welding results.	
	Students with advanced abilities often become informal mentors for their struggling peers.	
	The lack of modern welding machines or complete PPE is the main obstacle.	
	Some students still neglect K3 protocols (e.g., not consistently wearing welding helmets), especially in schools with less strict supervision.	
	Welding technology students are often considered a tough group because they are used to working in hot and noisy workshop environments.	
	Students are known as prospective ready-to-work laborers who are immediately absorbed into the industry.	

DISCUSSION

The characteristics of students in welding education indicate that safety competence (K3) and practical knowledge are the main foundations. This document emphasizes that students have been trained to use Personal Protective Equipment (welding helmets, gloves) and understand emergency procedures, but their implementation is often inconsistent in the workshop environment (Blunt & Balchin, 2002). Research (Mayombe, 2024) highlights the importance of an experiential learning approach to internalize safety protocols, such as fire incident simulations or exposure to hazardous gases. However, challenges arise when school facilities are inadequate (e.g., damaged PPE or outdated welding machines), which could potentially reduce the effectiveness of training (Shoko & Mberengwa, 2024). The study recommends collaboration with industry to provide modern tools and ISO/AWS standard-based training to ensure alignment with industry needs.

Student motivation in welding education is greatly influenced by the relevance of content to the workplace and a practice-based delivery system (W. Keller, 2010). Findings show that 72% of students are motivated by applied projects such as structural component fabrication but lose interest when it comes to theory. However, challenges arise when school facilities are inadequate (e.g., damaged PPE or outdated welding machines), which could potentially reduce the effectiveness of the training (Shoko & Mberengwa, 2024). Studies recommend collaboration with the industry to provide modern tools and ISO/AWS standard-based training to ensure alignment with industry needs. taught monotonously.

The implementation of the ARCS model (Attention, Relevance, Confidence, Satisfaction) through VR simulations and industrial internships has been proven to increase confidence, as observed by (J. M. Keller, 2016). On the other hand, negative attitudes arise due to the social stigma against vocational schools and limited facilities, exacerbated by the non-ideal student-to-machine ratio (10:1 in remote areas). The study (Jalinus et al., 2021) suggests the integration of blended learning and collaboration with industry to address this motivational disparity.

The group characteristics in welding education are dominated by male students (95%) with diverse economic and academic backgrounds. Heterogeneity triggers dynamics such as peer mentoring but hinders the participation of female or novice students (Park et al., 2017). Suryani et al. (2021) emphasize the need for differentiated instruction to accommodate differences in ability (Compen et al., 2024), for example, by dividing the class into small groups based on the level of mastery of welding techniques (1F to 3F). The social stigma against vocational schools and the pressure to work part-time reduce the study focus of students from economically disadvantaged families (Aldossari, 2020). The proposed solutions include special scholarship programs, gender awareness training for instructors, and strengthening partnerships with the industry to enhance the image of vocational education.

Context analysis shows significant differences in facilities between SMK Negeri 3 and 6 Palu. SMK Negeri 3, as a teaching factory school (Saputro et al., 2021) and an Excellence Program (PK), is equipped with exhaust fans and bending machines, while SMK Negeri 6 lacks ventilation facilities. Both schools face an ideal student-to-machine ratio (5–8 students/machine), which could potentially reduce effective practice time (Noguera et al., 2024). Although both provide complete PPE (auto-darkening helmets, leather gloves), budget constraints for machine repairs and the purchase of shielding gas (CO_2/Argon) hinder the smoothness of learning. The study (Aisah et al., 2021) emphasizes that adequate infrastructure and an ideal student-to-to-tool ratio are the main prerequisites for achieving competency according to SKKNI.

Collaboration with local industries, such as PT SSC Works Palu, can be a solution to provide modern tools and training based on ISO/AWS standards. Learning at both vocational schools adopts an experiential learning model, with 70% of the time allocated for hands-on practice in the workshop. Projects such as fabricating school gates or repairing household appliances enhance the relevance of learning (Özyıldırım et al., 2024).

However, both schools have not yet utilized virtual technology (e.g., VR welding simulator), even though a study (Abryandoko, 2024) has proven that digital simulations enhance the mastery of complex techniques such as vertical welding (3F) without physical risk. The involvement of industry practitioners as guest instructors (for example, underwater welding techniques) adds value, but there are still few instructors certified by BNSP/AWS (Thayeb & Santosa, 2021). Research (Zitha et al., 2023) recommends the integration of blended learning with digital platforms (such as Google Classroom) to optimize theory and practice learning, especially in schools with limited facilities.

Systemic challenges include budget constraints, a lack of certified instructors, and uncomfortable workshop conditions (high temperatures, noise). SMK Negeri 3 and 6 both face a shortage of specialized K3 experts, increasing the risk of practical accidents (Yurtçu, 2019).

The internship program has a positive impact, but it has not yet reached all students due to limited quotas. Suggestion (Nugraha et al., 2024) for an increase in government funding allocation for instructor training and safety equipment procurement. The recommendation (Watters et al., 2016) regarding partnerships with the industry for funding practical materials (steel, electrodes) is also relevant. Additionally, the adoption of VR welding simulators through CSR support from technology companies can be an innovative solution, while the enhancement of instructor certification is mandatory to ensure the quality of learning meets global standards.

CONCLUSION

Welding education in vocational schools prioritizes safety competence (K3) and practical knowledge as the main foundation. However, its implementation is often hindered by inadequate facilities, such as damaged PPE, outdated welding machines, and an unfavorable student-to-machine ratio (5–8 students/machine) that reduces the effectiveness of practical training. Collaboration with the industry is necessary to provide modern tools and ISO/AWS standard-based training to bridge the gap between the curriculum and industry needs. The study emphasizes that adequate infrastructure and proper budget allocation are the main prerequisites for achieving competence according to Indonesia's National Performance Competency Standards.

Project-based learning, such as the fabrication of structural components, has been proven to increase student motivation, while the experiential learning model strengthens the relevance of skills to the workplace. However, the low adoption of virtual technology (e.g., VR welding simulator) hinders the training of complex techniques such as vertical welding (3F). The integration of blended learning through digital platforms (Google Classroom) and the involvement of industry practitioners as guest instructors becomes a solution to optimize theory-practice learning, especially in schools with limited facilities.

SUGGESTION

Systemic challenges include budget constraints, a lack of BNSP/AWS certified instructors, and an uncomfortable workshop environment (high temperatures, noise). The risk of practical accidents increases due to the lack of specialized K3 experts. Therefore, an increase in government funding allocation is needed for instructor training, procurement of safety equipment, and the expansion of internship programs. Partnerships with the industry through CSR for the provision of VR welding simulators and practice materials (steel, electrodes) are also recommended to enhance the quality of learning in accordance with global standards. Thus, vocational welding education can produce competent graduates who are ready to compete in the era of Industry 4.0.

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Author Contributions

Muhtar.Suryanti.: The conception and design of the study. Muhtar.: The first draft of the manuscript and all authors commented on earlier versions of the manuscript. All authors read and approved of the final manuscript. Muhtar.: Idea for the article, Diyah Yustiana.: Identification problems and need analysis, Supriyanto. Nurwahyuddi. Muhamad Charis.: Data collection and primary study.

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