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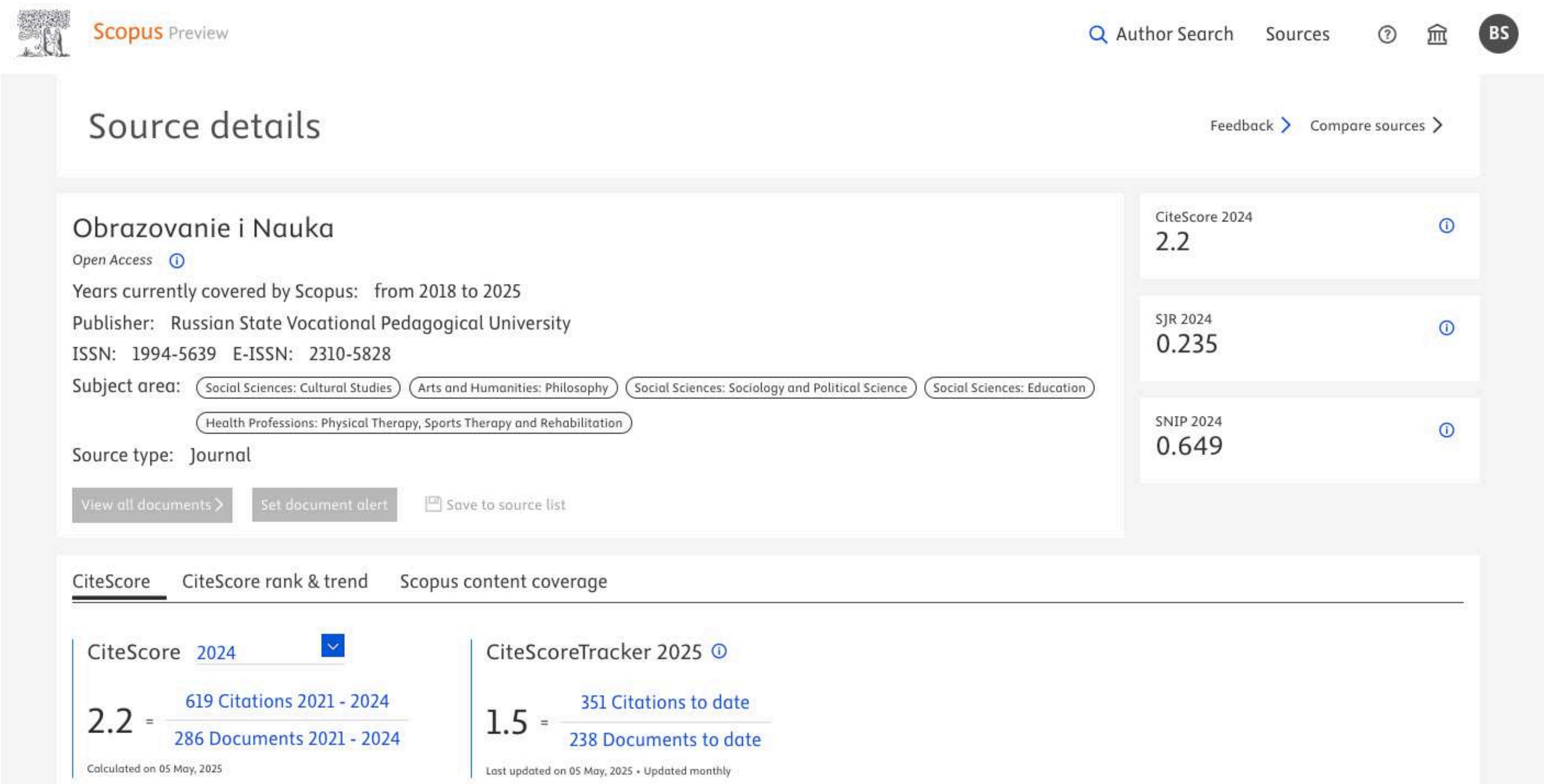

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B. Sudarsono, W.N.E. Saputra, F. A. Ghozali

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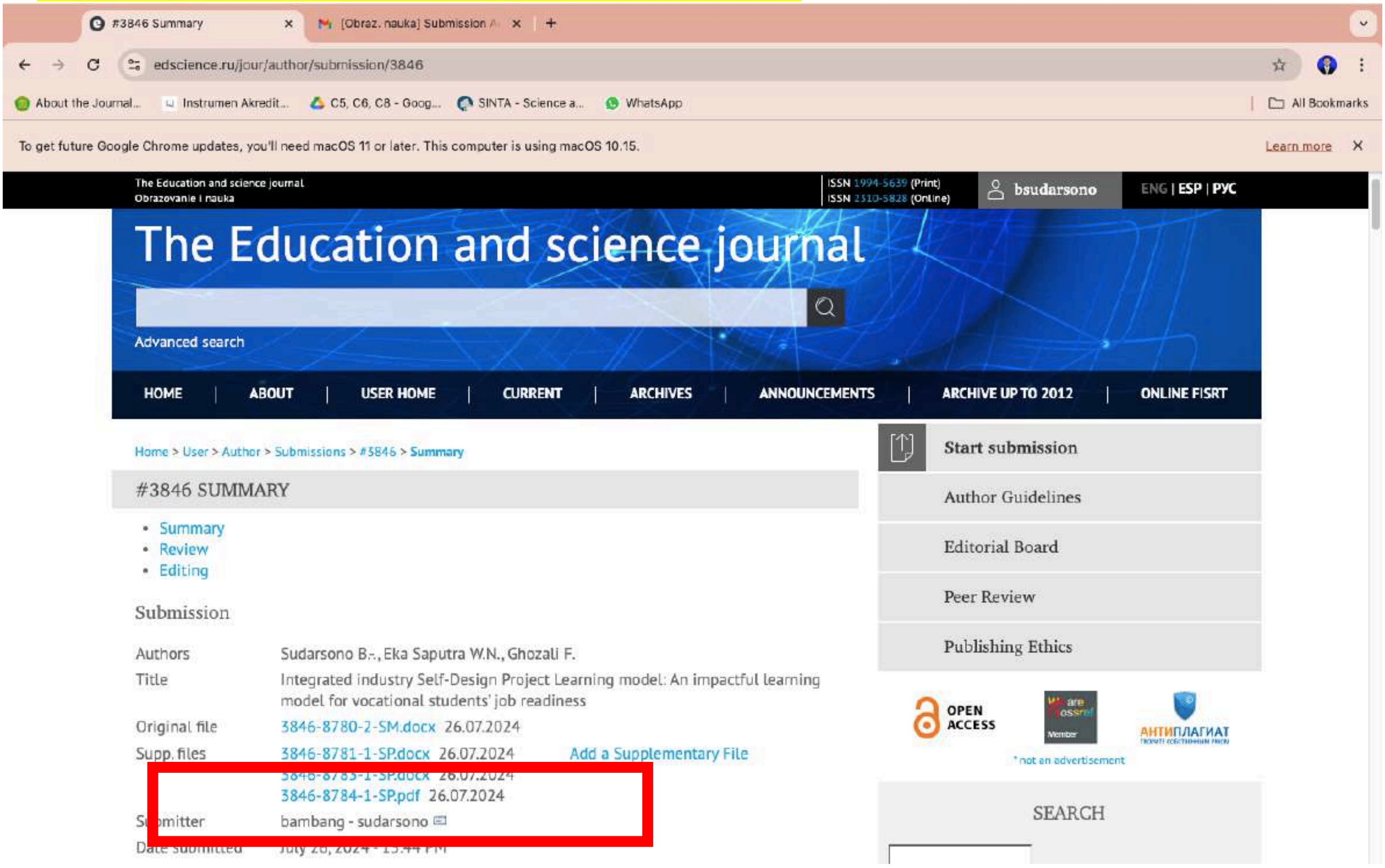

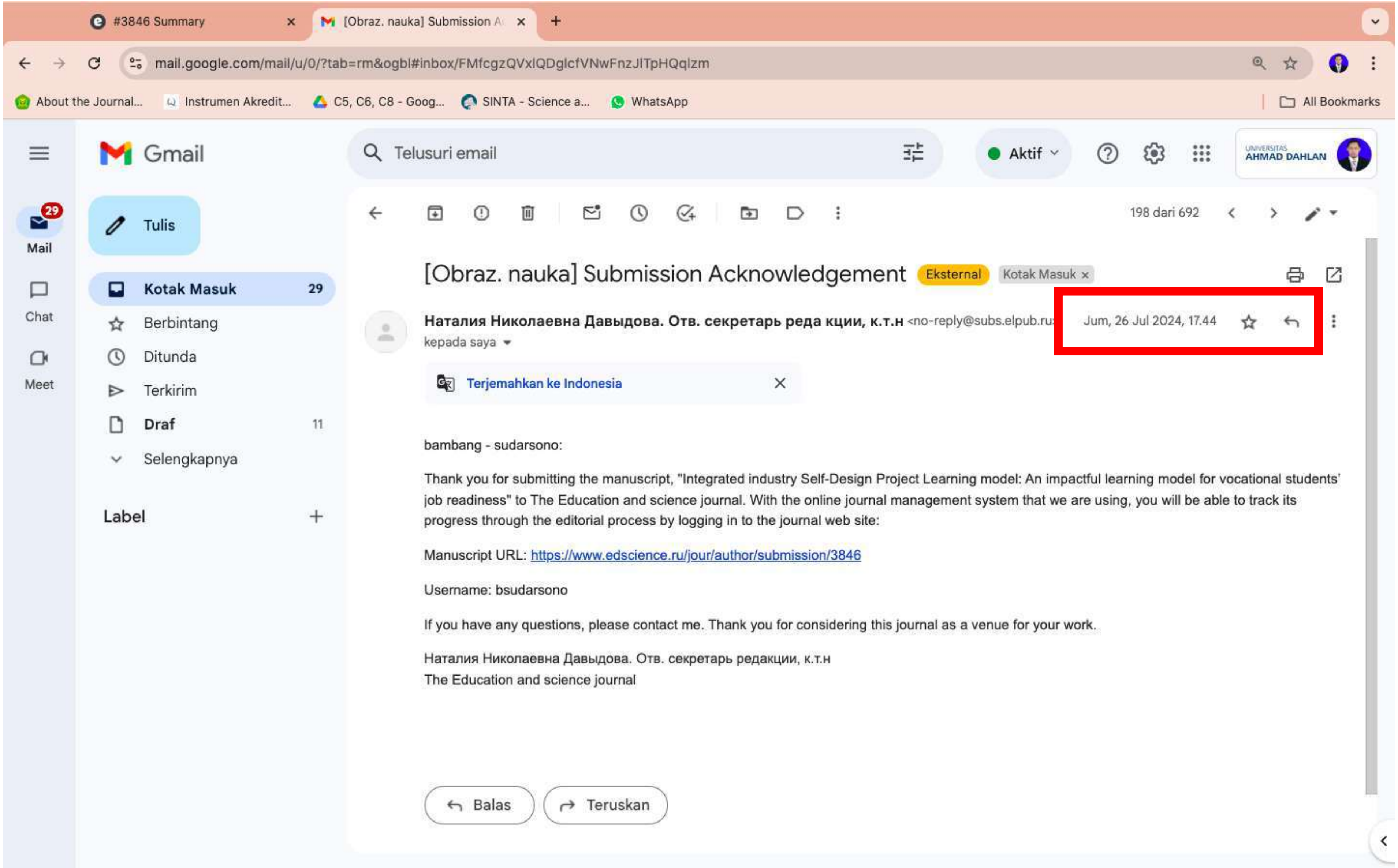

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ARTIKEL YANG DI SUBMIT

Integrated industry Self-Design Project Learning model: An impactful learning model for vocational students' job readiness

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Abstracts. *Abstracts*. Introduction. In 2023, graduates of Vocational High Schools (VHS) in Indonesia are still one of the highest contributors to the unemployment rate. This continuing problem is caused by the inadequate work readiness of VHS students. The main problem lies in the current educational approach which is still limited to vocational schools and less integrated with industry needs. *Aim*. The purpose of this study is to develop a product-based learning model that is aligned with industry needs and evaluate its effectiveness in improving the work readiness of vocational students. *Methodology and research methods.* This research was carried out in the stages of needs analysis, internal validation, and external validation. Data collection techniques consisted of test and non-test methods, using instruments such as interviews, questionnaires, and practical performance tests. *Results and scientific novelty*. The collected data were analyzed descriptively and the results were interpreted using categorization criteria. The findings show that the i-SDPL learning model and performance test measurement tools are very effective in the context of vocational education. Specifically, the i+SDPL learning model significantly enhanced students' work readiness, with average scores of 3.3 for attitude competency and 3.4 for both knowledge and skill competencies. The scientific novelty of the Self-Design Project Learning (SDPL) learning model lies in the integration of industry needs that enable students to develop competencies. Students are designed to carry out projects independently, thus fostering a deeper understanding of industry-relevant skills and knowledge. *Practical significance*. The implementation of the i-SDPL model is expected to encourage greater industry recognition of the competencies developed by VHS graduates and further strengthen the partnership pattern between VHS and industry.

Keywords**:** integrated industry, self-design project learning (i-SDPL), vocational students, job readiness

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Introduction

The fourth industrial revolution, known as Industry 4.0, has brought major changes in various sectors, including the world of work. In this era, the skills required by the workforce are no longer limited to technical abilities, but also include soft skills such as critical thinking, creativity, and the ability to collaborate. Vocational High Schools (VHS) in Indonesia, whose role is to produce a ready-made workforce, are faced with the challenge of adjusting their curriculum and teaching methods to suit the changing needs of the job market. Therefore, innovative learning approaches are needed that can bridge the gap between education and the world of work.

The industry-integrated Self-Design Project Learning (SDPL) model emerges as a potential solution to overcome these challenges. SDPL emphasizes on students' active involvement in designing and implementing industry-relevant projects. In this model, students not only learn about theoretical concepts, but also apply their knowledge in real situations. Thus, students can develop technical skills and soft skills that are highly needed in the workplace.

One of the advantages of SDPL is its ability to provide a more in-depth and contextualized learning experience for students. In their self-designed projects, students have to interact with various stakeholders, including teachers, industry professionals and peers. These interactions not only enrich their learning experience, but also help students build professional networks that can be useful in the future. In addition, students also learn to work in teams, resolve conflicts, and manage time effectively.

Integration with industry in SDPL provides opportunities for students to access the latest technology and practical knowledge that is not always available in an academic environment. Through collaboration with industry, students can keep up with the latest trends, understand market needs, and prepare themselves for upcoming challenges. This is especially important given the rapid changes in technology and the need for a flexible and adaptive workforce. Industry also benefits by being involved in the education process, such as identifying potential workforce candidates and contributing to the development of relevant curricula.

This study aims to explore the extent to which industry-integrated SDPL can improve the work readiness of vocational students. The main focus is to identify key elements of this learning model, such as project structure, industry involvement, and teacher support. In addition, the study will also assess the effectiveness of SDPL in improving students' technical skills and soft skills, as well as see how this model affects students' motivation and learning attitude. The study is expected to provide guidance for the development of a more relevant and contextualized curriculum in VHS.

The perceptions of stakeholders, including students, teachers and industry, will be the main focus in assessing the success of this learning model. Students are expected to provide feedback on their learning experience, the skills they have acquired, and the extent to which the projects they undertake are relevant to the world of work. Teachers will provide insights into the challenges and benefits of implementing SDPL, as well as how this model has affected their teaching methods. Industry, on the other hand, will provide perspectives on students' work readiness and how SDPL can bridge the gap between education and industry needs.

In addition, this research will also assess how SDPL can be adapted and implemented in different contexts. Given the diversity of VHSs in Indonesia, it is important to understand the factors that may influence the successful implementation of this model, such as support from school management, availability of resources, and linkages with industry. This study will explore various strategies that can be used to overcome these challenges, as well as evaluate how this model can be integrated with existing educational programs.

With the growing need for a ready and competent workforce, it is important to evaluate and update existing learning approaches. Industry-integrated SDPL offers an attractive model to improve the work readiness of vocational students. This article is expected to contribute significantly to the discussion on curriculum development and learning methodologies in vocational education. In addition, this research is also expected to provide practical guidance for other educational institutions interested in implementing similar approaches.

Overall, this research aims to provide a comprehensive insight into the development of an industry-integrated Self-Design Project Learning Model in VHS. By examining various aspects of this model, it is hoped that ways can be found to improve its effectiveness and provide maximum benefits for students. The results of this study will not only be useful for VHSs in Indonesia, but can also serve as a reference for vocational education institutions in other countries facing similar challenges.

Literature Review

Vocational High Schools (VHS) serve as educational institutions designed to prepare graduates for immediate entry into the workforce in their respective fields of expertise (Goldhaber et al., 2022; Tentama & Riskiyana, 2020). VHS play a crucial role in meeting the labor demands of various industrial sectors. Consequently, the quality of VHS graduates directly impacts industrial productivity. Well-prepared VHS graduates can seamlessly transition into the workforce, contributing effectively to their respective industries and enhancing overall productivity (Palilingan et al., 2020; Sukardi et al., 2022).

However, data from the Central Bureau of Statistics indicate that VHS graduates constitute the highest proportion of unemployed individuals, accounting for 9.6% of the total unemployment rate (Walidayni et al., 2023). This high unemployment rate among VHS graduates can be attributed to several factors, with the primary issue being their level of job readiness (Candra et al., 2023). Many graduates lack the necessary skills and practical experience demanded by employers, leading to a significant gap between education and employment. Addressing this issue requires a comprehensive approach to improve the vocational training curriculum, incorporate industry-specific skills, and provide real-world experience to enhance the employability of VHS graduates (Rodzalan et al., 2022; Schulz et al., 2023).

The readiness to enter the workforce among graduates of VHS is formed through a comprehensive learning process that includes theoretical instruction, practical training, and industry exposure (Prianto et al., 2021). Vocational high schools have been progressively enhancing the quality of their education by integrating advanced educational methods and updating their curricula to meet the evolving demands of the job market (Marniati & Witcjaksono, 2020; Prianto et al., 2021). These efforts encompass a variety of initiatives, including the adoption of modern teaching techniques, the improvement of learning facilities, and the use of technology-enhanced learning tools. Despite these advancements, the issue of high unemployment rates among VHS graduates remains a significant challenge, requiring further strategic interventions.

A critical component of addressing this challenge is the establishment of robust partnerships between vocational high schools and industries (Zhao et al., 2020). Such collaborations are essential for aligning the educational outcomes of VHS students with the specific skills, knowledge, and attitudes required by employers (Drewery et al., 2022). By engaging directly with industries, vocational schools can ensure that their curricula are not only relevant but also forward-looking, preparing students for current and future job market demands (McNamara, 2022; Young & Hordern, 2022). These partnerships facilitate the exchange of valuable insights and allow for the adaptation of teaching methodologies to better meet industry standards. Moreover, industry involvement in the education process can provide students with practical experience and real-world exposure, further enhancing their readiness for employment (Borah et al., 2021; Underdahl et al., 2023).

To effectively implement these industry-school collaborations, a systematic approach is required (García-Martínez et al., 2021; Nsanzumuhire & Groot, 2020). This includes conducting comprehensive needs analyses to identify the specific competencies demanded by various sectors, developing detailed task descriptions that outline the expected job roles, and establishing clear competency standards that serve as benchmarks for student performance. Additionally, creating rigorous assessment procedures is crucial for evaluating whether students have acquired the necessary skills and knowledge. These assessments should be designed in consultation with industry experts to ensure their relevance and accuracy. Through these collaborative efforts, vocational high schools can produce graduates who are not only academically proficient but also possess the practical capabilities and professional attitudes required to thrive in the workforce (Kholis et al., 2020; Syauqi et al., 2022).

The pivotal factor contributing to the effective cultivation of work readiness among graduates of VHS resides in the proactive engagement of the industry in establishing competency benchmarks for VHS graduates, encompassing attitudes, knowledge, and skills (McGrath & Yamada, 2023; Rachmawati et al., 2023; Rebia et al., 2023). Within the domain of VHS education, it is imperative to delineate minimum competency standards that students are required to attain, ensuring congruence with industry requisites. A pedagogical methodology garnering increasing attention in vocational education is Self-Design Project Learning (SDPL) (Jie et al., 2023). SDPL stands out as a pedagogical model deemed suitable for adoption within vocational education settings. The fundamental aim of the SDPL framework is to align the caliber of vocational graduates with industry exigencies (Hamdani & Suherman, 2021; Larson et al., 2020). SDPL is characterized by students acquiring proficiency in attitude, knowledge, and work skills through their engagement with products or projects. The SDPL framework comprises seven distinct stages, namely: (a) Product/Project Planning; (b) Implementation; (c) Inquiry and Development; (d) Collaboration; (e) Evaluation; (f) Presentation; and (g) Reflection (Almulla, 2020; Fauziah et al., 2023; Tejawiani et al., 2023).

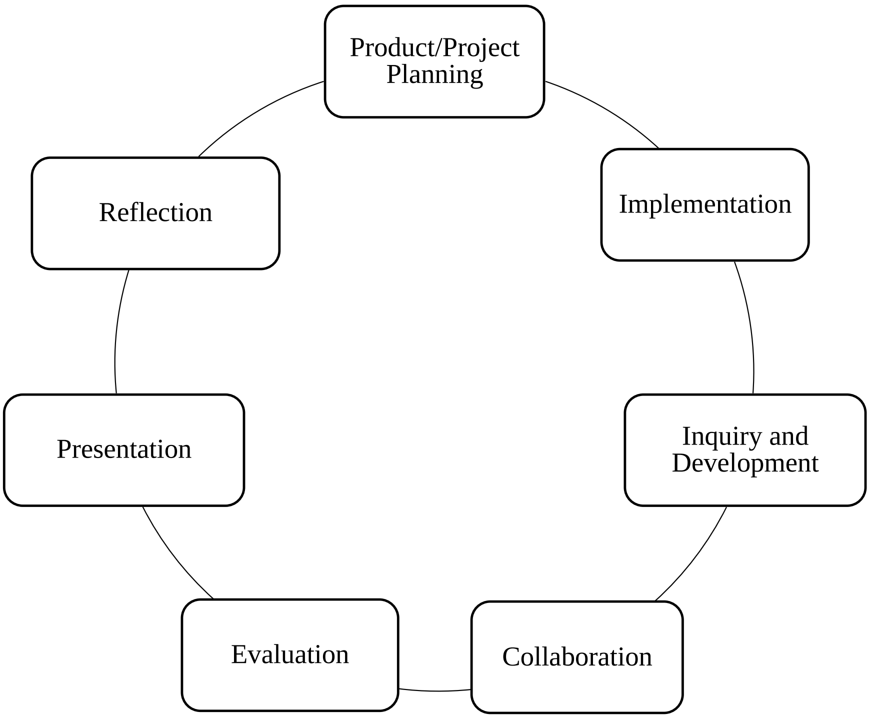

Fig. 1. Stages of the Self Design Project Learning (SDPL) Model

The i-SDPL (Integrated Project-Based Learning) model represents a refinement of traditional Project-Based Learning (PjBL), aimed at addressing the inherent limitations observed in the standard SDPL approach. Recent scholarly investigations, as documented by Hariyanto et al. (2023), Nilsook et al. (2021), and R. Zhang et al. (2023), have underscored deficiencies primarily pertaining to collaborative dynamics and the degree of industrial engagement within the educational milieu. These shortcomings have prompted a concerted effort to reconceptualize the SDPL framework, thereby fostering a more symbiotic relationship between academia and industry (Hariyanto et al., 2023; Nilsook et al., 2021; R. Zhang et al., 2023).

The integration of i-SDPL with industrial imperatives is multifaceted, encompassing several key facets. Firstly, it necessitates the alignment of educational objectives with the dynamic demands of contemporary industries. This alignment ensures that curricular content is not only relevant but also responsive to the evolving needs of the professional landscape. Secondly, the collaborative partnership between educators and industry stakeholders assumes paramount significance. By fostering close ties between these two spheres, i-SDPL endeavors to bridge the gap between theoretical knowledge and practical application, thereby imbuing students with a holistic understanding of their chosen vocation. Finally, the utilization of industrial infrastructure serves to immerse students in an authentic work environment, thereby providing firsthand exposure to the challenges and nuances of their respective industries.

Ultimately, the overarching goal of integrating the i-SDPL model with industry is to enhance the vocational preparedness of students enrolled in Vocational High Schools (VHS) while simultaneously mitigating the incidence of post-graduation unemployment. Through a synergistic blend of academic rigor and real-world applicability, i-SDPL seeks to empower students with the requisite skills and competencies to thrive in an increasingly competitive job market. Moreover, by fostering a culture of collaboration and partnership between academia and industry, i-SDPL not only serves the immediate interests of students but also contributes to the broader socio-economic development of the communities it serves (Colim et al., 2022; Maryani et al., 2020; Sudarsono et al., 2022; Sudira et al., 2022).

Methodology, Materials and Methods

This study employed Richey and Klein's research and development design, comprising three distinct stages of inquiry. The research and development process for the learning model described comprises three primary stages: Needs Analysis, Internal Validation, and External Validation. During the Needs Analysis stage, the primary objective is to gather comprehensive information on learning challenges, competencies and materials required for product/project-based learning as demanded by the industry, industry-integrated learning models, and Practical Performance Test instruments. This stage involves 10 teachers and 12 industry practitioners to ensure that learning needs are accurately identified and aligned with industry requirements.

The Internal Validation stage aims to obtain feedback from experts to ensure that the learning model and Practical Performance Test instruments are suitable for application in the External Validation stage. This stage involves 2 vocational education experts and 2 industry practitioners who assess the feasibility of the developed models and instruments. Their input is used to refine and adjust the models before wider testing. The External Validation stage focuses on evaluating the effectiveness of the learning model in enhancing students' work readiness. This process involves a series of tests and trials, beginning with a pretest involving 32 students, followed by a limited test with 20 students, and culminating in a broader trial with 136 students. This phased approach allows for a thorough evaluation of the learning model, from small groups to larger cohorts, ensuring its effectiveness and reliability in an educational setting.The sequential progression of these research stages is illustrated in Figure 2.

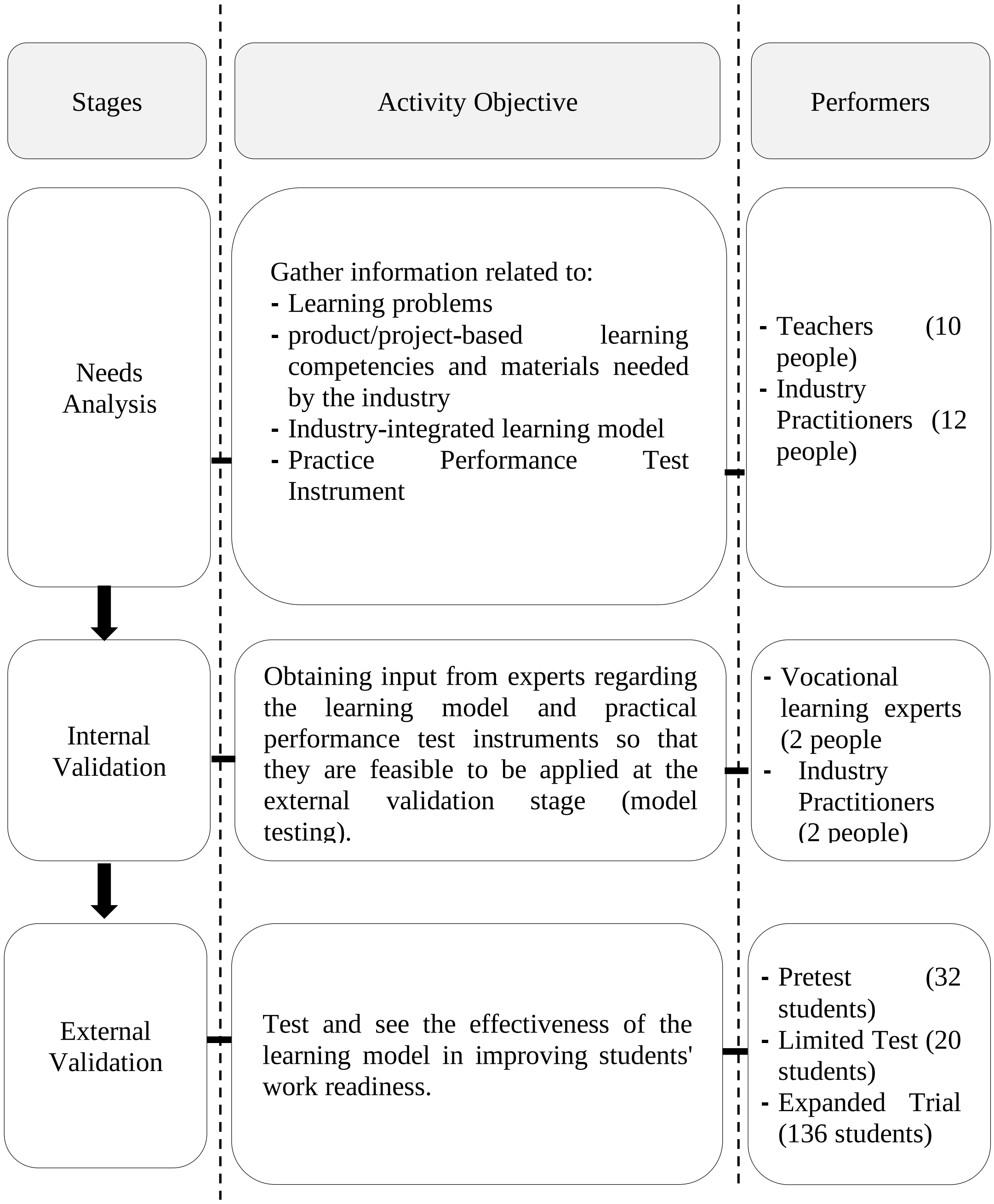

Fig. 2. Research and Development Procedures

The data collection methodologies employed in this study encompassed both test-based and non-test-based approaches. Non-test methodologies comprised interviews and questionnaires. The test-based methodology entailed a practical performance examination. Interviews were conducted through focused group discussions to glean insights into learning impediments, competencies, and the requisite product/project-oriented learning materials essential for industry integration.

Table 1

The internal validation instrument grids

No	Criteria	Assessment Indicators
1	Relevance	The learning model is relevant to the learning objectives to be achieved
2		The learning model is appropriate to the needs and characteristics of students.
3	Clarity	The instructions and steps in the learning model are clearly presented and easy to understand.
4	Readability	The language used in the learning model is easy to understand by students, teachers and industry practitioners.
5	Applicability	The learning model can be applied in the context of classroom learning
6	Effectiveness	The learning model is effective in improving aspects of student competence
7	Suitability to the Curriculum	The learning model is in accordance with the applicable curriculum and is able to support the achievement of basic competencies that have been determined
8	Industry participation	The learning model encourages industry participation

The questionnaire utilized was a viability assessment instrument to be completed by vocational and industrial education experts, aimed at evaluating the suitability of the learning model and practical performance assessments. This evaluation aids in determining the feasibility of the model for external validation (model testing). Concurrently, the practical performance tests were utilized to gauge the efficacy of the learning model in enhancing students' vocational preparedness. The internal validation instrument grids for experts and learning evaluation instruments can be seen in Table 1 and Table 2, respectively.

Table 2

Learning evaluation instruments

Competencies	Competency Aspect
Attitude	Thoroughness
	Teamwork
	Hard Work and Discipline
	Creativity and Innovation
Knowledge	Technical Knowledge
	Material Knowledge
Skills	Mechanical Skills
	Information Technology Skills

The validity and reliability of the interview, questionnaire, and performance test instruments were assessed through rigorous content validity tests conducted by experts drawn from the realms of vocational learning and industry. Specifically, these experts held positions as car service advisors, ensuring a specialized understanding of the subject matter. Reliability testing, on the other hand, was executed utilizing the Cronbach Alpha (α) test, a renowned measure known for its ability to ascertain internal consistency reliably. The outcomes consistently affirmed the instruments' reliability. The assessment instrument for the student practical performance test underwent meticulous development, spearheaded by VHS Automotive Engineering educators, automotive industry practitioners, and vocational learning authorities. Drawing upon the seminal research titled 'Development of an Industry-Oriented Experiential Learning (EL+i) Model to Enhance Vocational High School Students' Job Readiness', as delineated in Table 3, the instrument was tailored to suit the exigencies of the study.

Table 3

Categorization Of Questionnaires and Practical Performance Tests

Score	Category
3.01 - 4.00	Very Effective
2.51 - 3.00	Effective
2.01 - 2.50	Less effective
0 - 2.00	Ineffective

(Sudarsono et al., 2023)

Quantitative data analysis served as the cornerstone for evaluating both the model's feasibility questionnaire instrument and the practical performance assessment instrument, alongside the subsequent analysis of the practical performance test results. This analytical approach facilitated comprehensive categorization and interpretation of the amassed data.

Research Results

Needs Analysis

The needs analysis stage aims to investigate learning challenges, required competencies, and the product or project-based learning materials necessary for industry integration. Data analysis was conducted through focus group discussions involving participants from vocational high school automotive engineering teachers and automotive industry practitioners. The findings from the needs analysis stage are presented in Table 4, Table 5, and Figure 3. The results indicate that the current industry demands product and project-based learning materials, specifically in the areas of electric vehicle modification, gas and electric welding, and oven painting.

Table 4

Learning problems

No	Indicators	Vocational School Teachers	Industry Practitioners
1.	Learning Planning	Teachers plan lessons in accordance with the instructions of related	VHSs do not collaborate with industry in lesson planning.

		agencies; there is no role for industry.	
2.	Learning Implementation	During this time, the implementation of learning is done by teachers themselves; the role of industry is absent.	VHSs passively collaborate and cooperate with industry in the implementation of learning.
3.	Evaluation of Learning	VHS-based evaluation; no industry role.	VHSs collaborate with industry only to the extent of graduation competency tests at the end of the learning period, not gradually according to competency levels.
4.	Graduate Quality	The quality of graduates is not certified by the industry.	The quality of graduates depends on the results of the VHS process, while industry contributes minimally.

The analysis reveals significant deficiencies in the collaboration between vocational high schools and industry in planning, implementation, evaluation, and graduate quality. Teachers plan curricula based on institutional directives without industry input, and learning is conducted solely by educators, indicating a lack of industry involvement. Evaluation is primarily managed by vocational high schools, with industry participation limited to graduation competency tests, resulting in graduates lacking industry certification. To address these issues, it is recommended to establish partnerships between vocational high schools and industry to co-develop curricula that integrate current industry standards and practices. Industry professionals should actively participate in teaching and provide practical training, while continuous evaluation involving industry practitioners should be implemented to ensure students meet required competencies. Additionally, a certification process developed in collaboration with industry should validate graduates' skills and knowledge, thereby enhancing their employability and ensuring vocational education aligns with current industry standards.

Table 5

Competencies required by industry

Competencies	Competency Aspect	Description
Attitude	Thoroughness	Ability to perform work with detail and accuracy.
	Teamwork	Ability to work with others in a team, collaborate and support each other to achieve common goals.
	Hard Work and Discipline	Ability to complete tasks in a timely manner and to a high standard of quality.
	Creativity and Innovation	Ability to think beyond predictions, seek new solutions, or improve existing processes.
Knowledge	Technical Knowledge	Ability about the principles, concepts, and specific details of a field of technology or science.
	Material Knowledge	Ability about different types of materials, their properties, their optimal use, and ways of processing and application in various contexts.
Skills	Mechanical Skills	The practical ability to understand, maintain, repair and work with mechanical equipment, machines and components.
	Information Technology Skills	The ability to use software and related technologies, such as automotive information management software, analysis systems, and other software that support automotive industry operations.

The listed competencies are comprehensive and encompass essential areas for vocational students, particularly those specializing in electric vehicles. Attitude-related competencies prepare students to work effectively and innovate within teams. Knowledge-based competencies provide the theoretical foundation necessary for understanding and applying technical concepts. Skill-related competencies ensure students can perform practical tasks and utilize modern technologies proficiently. Integrating these competencies into vocational education can significantly enhance students' readiness for the workforce, especially in technical and rapidly advancing fields such as electric vehicle technology.

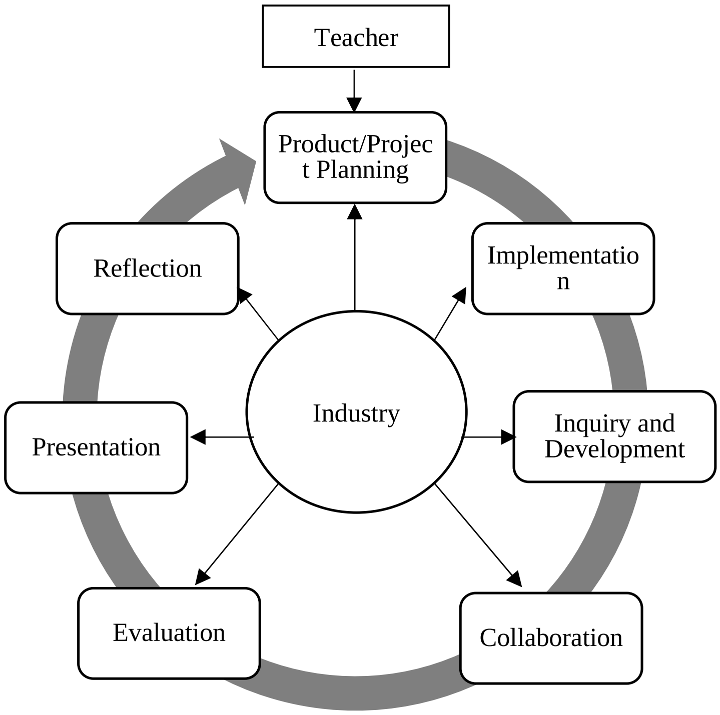

Fig. 3. SDPL Learning Model from Needs Analysis (Conceptual)

Internal Validation

The internal validation stage aims to gather input from experts on the learning model and practicum performance test instruments, which will be applied in the external validation stage (trial). Experts involved in the internal validation stage include: (a) vocational learning lecturers with over 15 years of academic experience, automotive competency certificates, and relevant work in automotive engineering, and (b) industry practitioners with over 10 years of experience as service advisors or workshop heads.The results of the internal validation indicate that the practical performance assessment instrument aligns with the measured competencies, rubric criteria, and scoring.

Regarding the industry-integrated i+SDPL learning model, the following are key points generated from the internal validation stage: (a) i+SDPL emphasizes collaboration between industry and educators at every stage of the model. (b) Implementation of the model is feasible in both vocational schools and industry, taking into account the availability of learning facilities and infrastructure. (c) Evaluation occurs in the industry with graduation standards aligned with industry needs. The revised i+SDPL learning model, incorporating feedback from the internal validation stage, is illustrated in Figure 4.

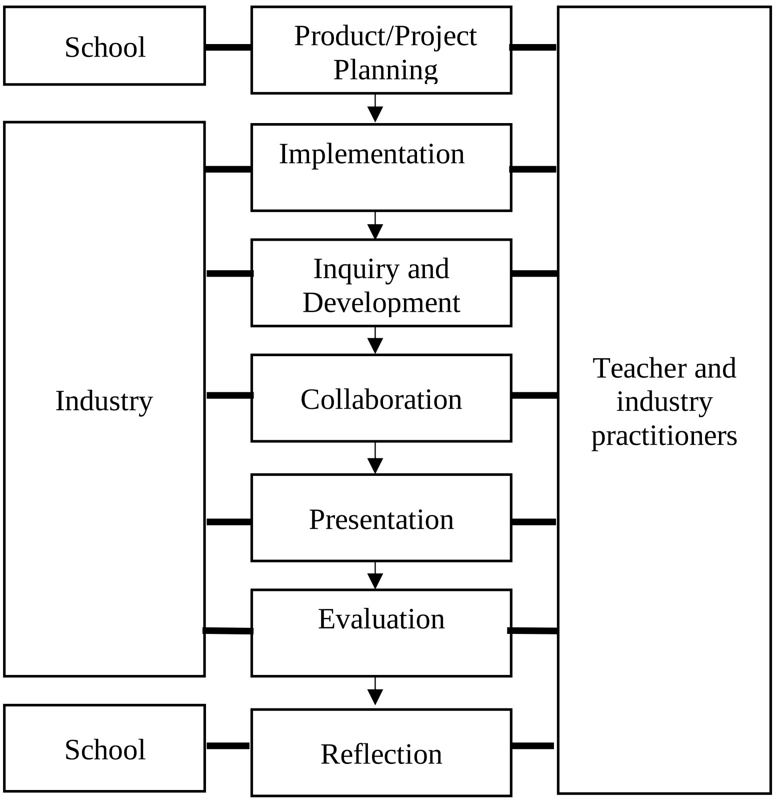

Fig. 4. Used Industry Integrated Self Design Project Learning Model (i+SDPL)

The PBL+T model, as delineated in the table, offers a comprehensive sequence of stages aimed at augmenting student learning through active engagement with both industry practitioners and educators. The initial product/project planning stage involves establishing clear learning objectives, selecting appropriate projects/products, and scheduling their implementation.

During the implementation stage, students participate in hands-on work aligned with the predefined plan, under the guidance of teachers and industry practitioners, ensuring adherence to industry standards. This phase is crucial for grounding theoretical knowledge in practical applications.

Subsequently, the inquiry and development stages enable students to complete their projects/products by applying the acquired knowledge and skills, with continuous support from industry practitioners and educators. The hallmark of the collaboration stage is direct interaction with industry practitioners, where students work closely with these professionals, gaining insights into real-world practices. Finally, the presentation stage allows students to showcase the outcomes of their projects/products, demonstrating their understanding and application of the learned concepts. This structured approach not only enhances the learning experience but also bridges the gap between academic knowledge and industry practices, preparing students for future professional endeavors.

Throughout the process, periodic evaluations are conducted by teachers and industry practitioners. These evaluations include competency tests and feedback aligned with industry standards. The final stage, reflection, allows teachers and industry practitioners to assess the learning outcomes and strategize future steps for further student competency development.

Table 4

Stages of Industry Integrated Self Design Project Learning Model (i+SDPL)

Model Stages	Activities	Time
Product/Project Planning	Industry Practitioner and Teacher together: Determine learning objectives Determine the project or product that will be used for learning Inform students about the work plan and schedule for learning implementation Divide the group	Before learning

Implementation	Students start practicing and working according to the projects planned by teachers and industry practitioners Industry Practitioners and Teachers together provide guidance to students when needed	According to industry standards
Inquiry and Development	Students complete a project/product Apply the attitudes, knowledge and skills gained from learning Industry Practitioners and Teachers together provide guidance to students when needed	
Collaboration	Students interact with industry practitioners who are experienced in completing projects / products	
Presentation	Students present the results of the project / product that is done	10 minutes/group
Evaluation	Teachers and industry practitioners evaluate student progress on a regular basis Teachers or industry practitioners conduct competency tests Teachers and industry practitioners summarize and provide feedback to students	As per industry standard
Reflection	Teachers and industry practitioners reflect on learning outcomes and plan steps for student competency development.	At the end of the lesson

External Validation

The external validation stage is divided into two: limited trial and extended trial stages. The purpose of external validation is to determine the effectiveness of the i+SDPL model in improving the work readiness of vocational students. External validation activities began with a pretest involving 32 students of VHS Muhammadiyah 2 Tempel. The subject matter tested was welding with a motorcycle chain cover project. The limited trial was conducted at VHS Muhammadiyah 1 Salam Magelang involving 20 students who studied welding with a toolbox project. Meanwhile, the extended trial was conducted at SMK Muhammadiyah 1 Salam and SMK Muhammadiyah Pakem, involving 136 students from the Automotive Engineering Department.

The analysis of the table indicates significant improvements across various categories attitude, knowledge, and skills from pretest to posttest. In the attitude category, there was a notable increase in creativity and innovation, with scores rising from 1.4 in the pretest to 3.6 in the posttest. Although some categories, such as conscientiousness and hard work and discipline, experienced a decline during the trials stage, both showed significant improvement in the posttest. The knowledge category also demonstrated a positive upward trend, with material knowledge increasing from 1.6 in the pretest to 3.6 in the posttest. Similarly, the skills category exhibited growth, with information technology skills improving from 1.4 in the pretest to 3.4 in the posttest.

Overall, these results suggest that the implemented program or intervention was successful in enhancing participants' attitudes, knowledge, and skills, despite some fluctuations during the trials stage. This indicates that, despite initial challenges, participants were able to overcome and significantly improve their abilities through the learning process or intervention conducted. The results of the external validation stage can be seen in Figure 5.

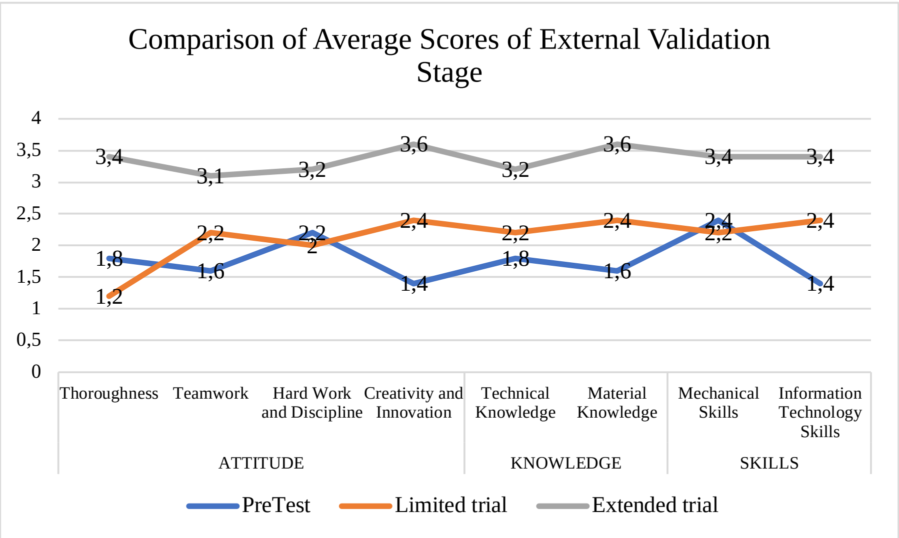

Fig. 5. Comparison of Average Scores of External Validation Stage

Results and Discussion

The Industry Integrated Self Design Project Learning (i+SDPL) Model, derived from the Project-Based Learning (PjBL) framework, emphasizes the development of student competencies through direct engagement with industry-related projects and products (Guile & Spinuzzi, 2023; Tejawiani et al., 2023; Youyou & Kit, 2023). This model integrates theoretical and practical learning, fostering a holistic development of attitudes, knowledge, and skills. Key characteristics of the i+SDPL model include its collaborative approach, where educators and industry practitioners work together to guide students. The curriculum is aligned with industry standards, ensuring that the competencies students acquire are relevant and up-to-date with current industrial demands. Furthermore, the model includes rigorous stages of implementation and evaluation, conducted within industrial settings, which immerse students in real-world work environments. This not only bridges the gap between classroom learning and industry practice but also facilitates a smoother transition for students into the workforce.

In the i+SDPL learning model, the integration of project- and product-based learning with industry standards is pivotal in shaping student competencies to meet industry needs. By working on real-life industry projects, students gain practical experience and develop skills that are directly applicable in their future careers. This experiential learning approach not only enhances technical proficiency but also fosters critical thinking, problem-solving, and collaboration skills. Exposure to the industrial climate plays a crucial role in preparing students for professional environments by enhancing their understanding of industrial processes and work culture. This comprehensive exposure helps in developing the character and work readiness of vocational high school (VHS) students, making them more adaptable and capable of meeting the challenges of the modern industrial landscape (Marnewick, 2023; Pan et al., 2023; Yudiono et al., 2021). The i+SDPL model, therefore, represents a significant advancement in vocational education by ensuring that students are not only academically proficient but also industry-ready.

The i+SDPL learning model has been demonstrated to be highly effective in enhancing work readiness across various dimensions, including attitudes, knowledge, and skills. This model significantly improves competence in the attitude of accuracy. Project-based learning, a core component of the i+SDPL model, emphasizes the final product's quality. To achieve a high-quality product, students must meticulously attend to every detail and ensure that each step is executed carefully, thereby consistently developing a thoroughness attitude (Issa & Khataibeh, 2021). Additionally, the i+SDPL learning model is an effective method for fostering competence in teamwork attitudes. The collaborative nature of the product creation process necessitates that teams work together to find solutions, enhancing students' abilities to engage in discussions, listen to other team members' opinions, and reach consensus beneficial to all parties involved parties (Aydın & Mutlu, 2023; Usmeldi & Amini, 2022).

The competency of hard work and discipline refers to a person's ability to complete tasks on time with high quality standards. Through the application of the i+SDPL learning model by producing projects or products, students can create work that meets industry standards, which emphasize completeness, efficiency and perfection. With the consistent application of i+SDPL, an optimal attitude of hard work and discipline will be formed (Tran & Tran, 2020; Zen et al., 2022; L. Zhang & Ma, 2023). The next attitude competency is creativity and innovation. The application of i+SDPL will strengthen students' creativity and innovation attitude. In the process of making products, students repeatedly receive feedback/direction from industry practitioners and teachers. The process encourages students to always innovate, looking for new ways to improve the quality of the products they produce, so that their competencies in creativity and innovation develop progressively (Ahmad & Jabu, 2023; Hanif et al., 2019; Ummah et al., 2019).

The i+SDPL learning model stimulates students to understand and apply concepts and theories in product manufacturing. Through the i+SDPL learning model, students more easily understand the relevance and importance of technical knowledge in practical applications. Not only that, but this model also facilitates students to directly experience the process and challenges of completing a project or product. These activities encourage students to develop technical skills from planning, implementation, to evaluation (Shin, 2018; Syahril et al., 2022). Furthermore, the i+SDPL learning model enhances students' material knowledge competency. The industry-integrated approach of i+SDPL emphasizes that application in completing projects or products will shape students' attitudes, knowledge and work skills. Students can observe how material theories and concepts are applied in real situations of making projects or products. The industry-based product-based learning model provides a deep understanding of the use and processing of materials in a practical context (Miller & Krajcik, 2019; Nasir et al., 2019; Wijayati et al., 2019).

Mechanical skills competency refers to a person's practical ability to understand, maintain, repair and operate equipment and machine components. The i+SDPL learning model is developed in accordance with industry needs and standardization. Through the application of the model, students get the opportunity to apply mechanical theories and concepts in making projects or products. Working according to industry standards, students are able to understand how mechanical principles apply in a real industrial context (Chao et al., 2019; Kurniawan & Budiono, 2018; Maksum & Purwanto, 2022; Syahril et al., 2021). The project-based learning model integrated with industry can improve the competence of information technology skills. Through the completion of industry-standard projects or products, students have the opportunity to interact with a variety of tools, platforms and information technologies commonly used in the industrial world (Granado-Alcón et al., 2020; Suswanto et al., 2017; J. Zhang et al., 2018). These learning activities equip students with practical and technical skills in operating, maintaining and utilizing various solutions using information technology (Al-Abdullatif & Gameil, 2021; Llorent et al., 2022).

Conclusion

The i+SDPL learning model is an innovative approach derived from the Project-Based Learning (PjBL) framework. This model's development stems from a comprehensive needs analysis and feedback from industry experts and practitioners. The distinguishing feature of the i+SDPL model is the integration of industry involvement at every stage of the learning process, including preparation, implementation, and evaluation. Moreover, the i+SDPL model is executed in a blended format, combining learning experiences in vocational high schools (VHS) and industry settings. The industry component is designed to acquaint students with the professional work environment at an early stage.

The i+SDPL learning model has demonstrated its efficacy in enhancing competencies in attitude, knowledge, and work skills through two trial implementations. The model's application is intended to benefit not only students but also teachers. For educators, the i+SDPL model serves as a mechanism to update and expand their knowledge in line with current industry advancements.

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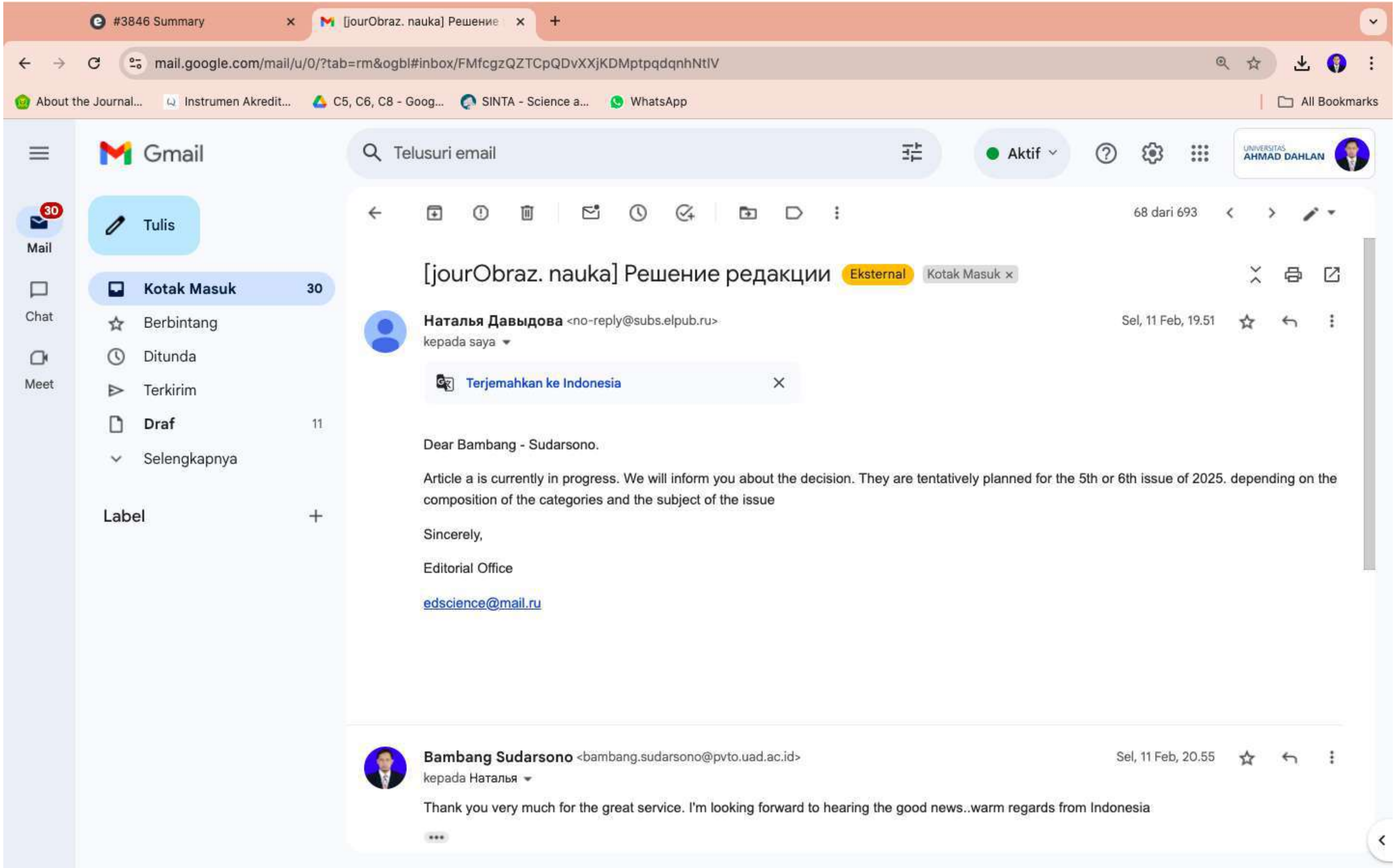
C. ROUND 1 (REVIEW 1)



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The decision of our Editorial Board: **The article can be published after revision.**

The reviewer has got some questions and comments to adjust the manuscript:

1. In the introduction, it is advisable to clearly articulate the problem and hypothesis of the study, as well as to provide a comprehensive list of tasks.
2. What can serve as the foundation for aligning mutual interests and goals when integrating i-SDPL with the demands of contemporary industries?
3. The author's interpretation of the Self-Design Project Learning model needs clarification.
4. How is model performance measured? What indicators and criteria are used to assess competence? This aspect is not clearly addressed in the study.
5. What are the limitations of the model, and how can they be addressed?
6. What are the motivating factors for all participants in the model?

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HASIL CATATAN DAN PERBAIKAN ROUND 1

	(20 Februari 2025)		
No	Bagian yang Revisi	Perbaikan	Halaman
1	In the introduction, it is advisable to clearly articulate the problem and hypothesis of the study, as well as to provide a comprehensive list of tasks	The Fourth Industrial Revolution, known as Industry 4.0, has brought about major changes in various sectors, including the world of work. In this era, the skills required are no longer limited to technical abilities, but also include soft skills such as critical thinking, creativity, and the ability to collaborate. Vocational high schools (VHSs) in Indonesia aim to produce a workforce that is competent and ready to face the world of work. Therefore, adjustments are needed in the curriculum, learning methods, and competency standards to suit industry needs. However, there is still a gap between the world of education and the world of work, which causes VHS graduates to not be fully prepared to face challenges in the industry	2
2		The industry-integrated Independent Design Project Learning (i-SDPL) model is emerging as a potential solution to address these challenges. i-SDPL is an extension of the existing SDPL model and emphasises the active involvement of students in designing and implementing relevant projects in learning. The main difference with the current SDPL model is that i-SDPL emphasises the active involvement of students in designing and implementing industry-relevant projects. In this model, students not only learn about theoretical concepts, but also apply their knowledge in real situations. Thus, students can develop technical skills and soft skills that are highly needed in the world of work. One of the advantages of i-SDPL is its ability to provide a more in-depth and contextualised learning experience for students. In their self-designed projects, students have to interact with various stakeholders, including teachers, industry professionals and peers. These interactions not only enrich their learning experience, but also help students build professional networks that can be useful in the future. In addition, students also learn to work in teams, resolve conflicts, and manage time effectively.	2
3	What can serve as the foundation for aligning mutual interests and goals when integrating i-SDPL with the demands of contemporary industries?	Students are expected to provide feedback on their learning experience, mastery of technical and soft skills, and the relevance of the project to industry needs. Teachers will provide perspectives on implementation challenges, benefits for improving the quality of learning, and the impact on teaching methods applied in the classroom. Meanwhile, the industry will assess students' work readiness, identify skills gaps, and provide recommendations to enhance the integration of SDPL with evolving industry demands.	3
4		Students are expected to provide feedback on their learning experience, mastery of technical and soft skills, and the relevance of the project to industry needs. Teachers will provide perspectives on implementation challenges, benefits for improving the quality of learning, and the impact on teaching methods applied in the classroom. Meanwhile, the industry will assess students' work readiness, identify skills gaps, and provide recommendations to enhance the integration of SDPL with evolving industry demands.	3
5	The author's interpretation of the Self-Design Project Learning model needs clarification	Overall, this research aims to provide a comprehensive insight into the development of an industry-integrated Self-Design Project Learning Model in SMK. By examining various aspects of this model, it is hoped that ways can be found to improve its effectiveness and provide maximum benefits for students. The results of this research are not only relevant for VHSs in Indonesia, but can also serve as a reference for vocational education institutions in other countries facing similar challenges	5
6	How is model performance measured? What indicators and criteria are used to	The performance of the i+SDPL model is measured based on three main competency aspects with clear indicators and criteria: (a). Attitude: Assessed through rigour, teamwork, hard work and discipline, as well as creativity and innovation, which reflect students' readiness in a real work environment. (b) Knowledge: Measured based on	4

	assess competence? This aspect is not clearly addressed in the study.	technical understanding and material knowledge required by the industry, ensuring students master the theory and its application. (c) Skills: Covers mechanical and information technology skills, which form the basis of industrial practice and the use of modern technology	
7	What are the limitations of the model, and how can they be addressed?	The i+SDPL model has several limitations that can affect its effectiveness. One of the main challenges is the limited collaboration with industry, especially for schools that do not have easy access to relevant companies. This can be overcome by building a wider network of partnerships through internship programmes, curriculum cooperation and industry visits. In addition, limited resources and infrastructure in some schools are also an obstacle in implementing this model. Solutions that can be applied are the utilisation of simulation technology, cooperation with companies for access to industrial facilities, and procurement of equipment through educational grants. On the other hand, students' level of independence in learning varies, which can affect the smooth running of their projects. To overcome this, initial training on project management, more intensive guidance from teachers and industry mentors, and periodic evaluations are needed to ensure students' progress. In addition, the evaluation of competency standards is also a challenge due to differences in industry standards that may affect the objectivity of the assessment. Therefore, the development of a standardised assessment rubric with the industry is a solution to ensure a more accurate evaluation and in accordance with the needs of the world of work. An explanation of these limitations and their solutions can be included in the Discussion section to provide insight into the challenges of i+SDPL implementation and strategies to improve its effectiveness.	25
8	What are the motivating factors for all participants in the model?	For teachers, motivation comes from their role as facilitators who not only teach theory but also guide students in industry-based projects. This model allows teachers to update their insights through co-operation with industry as well as develop more innovative and effective learning methods. In addition, students' success in producing quality projects is a source of satisfaction for educators. For the industry, involvement in SDPL is an opportunity to get a more prepared and skilled workforce candidate according to the company's needs. By participating in the design and evaluation of projects, industries can ensure that graduates have competencies that meet their standards. In addition, this model also helps the industry to build close relationships with educational institutions, which can lead to wider cooperation in the future	24
9	Perbaikan nomor sitasi	Sudah diperbaiki	
10	Perbaikan Gambar 5	Sudah diperbaiki	21

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Integrated industry Self-Design Project Learning model: an impactful learning model for vocational students' job readiness

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Abstracts. *Abstracts*. Introduction. In 2023, graduates of Vocational High Schools (VHS) in Indonesia are still one of the highest contributors to the unemployment rate. This continuing problem is caused by the inadequate work readiness of VHS students. The main problem lies in the current educational approach which is still limited to vocational schools and less integrated with industry needs. *Aim*. The purpose of this study is to develop a product-based learning model that is aligned with industry needs and evaluate its effectiveness in improving the work readiness of vocational students. *Methodology and research methods.* This research was carried out in the stages of needs analysis, internal validation, and external validation. Data collection techniques consisted of test and non-test methods, using instruments such as interviews, questionnaires, and practical performance tests. *Results and scientific novelty*. The collected data were analyzed descriptively and the results were interpreted using categorization criteria. The findings show that the i-SDPL learning model and performance test measurement tools are very effective in the context of vocational education. Specifically, the i+SDPL learning model significantly enhanced students' work readiness, with average scores of 3.3 for attitude competency and 3.4 for both knowledge and skill competencies. The scientific novelty of the Self-Design Project Learning (SDPL) learning model lies in the integration of industry needs that enable students to develop competencies. Students are designed to carry out projects independently, thus fostering a deeper understanding of industry-relevant skills and knowledge. *Practical significance*. The implementation of the i-SDPL model is expected to encourage greater industry recognition of the competencies developed by VHS graduates and further strengthen the partnership pattern between VHS and industry.

Keywords: integrated industry, self-design project learning (i-SDPL), vocational students, job readiness

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Интегрированная модель обучения в рамках отраслевого проекта по самостоятельному проектированию: эффективная модель обучения для повышения готовности студентов профессиональных учебных заведений к работе

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Аннотация. *Вступление.* В 2023 году выпускники профессионально-технических училищ (VHS) в Индонезии по-прежнему являются одним из самых высоких источников безработицы. Эта сохраняющаяся проблема вызвана недостаточной готовностью студентов VHS к работе. Основная проблема заключается в нынешнем образовательном подходе, который по-прежнему ограничен профессиональными учебными заведениями и в меньшей степени интегрирован с потребностями промышленности. Цель. Целью данного исследования является разработка модели обучения, основанной на продукте, которая соответствует потребностям отрасли, и оценка ее эффективности в повышении готовности к работе студентов профессиональных учебных заведений.
Методология и методы исследования Данное исследование проводилось на этапах анализа потребностей, внутренней и внешней валидации. Методы сбора данных включали в себя тестовые и непроверенные методы с использованием таких инструментов, как интервью, анкетирование и практические тесты эффективности. Результаты и научная новизна. Собранные данные были проанализированы описательно, а результаты интерпретированы с использованием критериев категоризации. Полученные результаты показывают, что модель обучения i-SDPL и инструменты измерения результатов тестов очень эффективны в контексте профессионального образования. В частности, модель обучения i+SDPL значительно повысила готовность студентов к работе: средний балл за отношение к работе составил 3,3 балла, а за знания и навыки - 3,4 балла. Научная новизна модели обучения самостоятельному проектированию (SDPL) заключается в интеграции отраслевых потребностей, которые позволяют студентам развивать компетенции. Студенты разрабатываются для самостоятельного выполнения проектов, что способствует более глубокому пониманию навыков и знаний, имеющих отношение к отрасли. Практическая значимость. Ожидается, что внедрение модели i-SDPL будет способствовать более широкому признанию отраслью компетенций, приобретенных выпускниками VHS, и дальнейшему укреплению партнерских отношений между VHS и промышленностью.

Ключевые слова:

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Introduction

The Fourth Industrial Revolution, known as Industry 4.0, has brought about major changes in various sectors, including the world of work. In this era, the skills required are no longer limited to technical abilities, but also include soft skills such as critical thinking, creativity, and the ability to collaborate [1, 2]. Vocational high schools (VHSs) in Indonesia aim to produce a workforce that is competent and ready to face the world of work [3, 4, 5]. Therefore, adjustments are needed in the curriculum, learning methods, and competency standards to suit industry needs. However, there is still a gap between the world of education and the world of work, which causes VHS graduates to not be fully prepared to face challenges in the industry.

The industry-integrated Self Design Project Learning (i-SDPL) model is emerging as a potential solution to address these challenges. i-SDPL is an extension of the existing SDPL model and emphasises the active involvement of students in designing and implementing relevant projects in learning. The main difference with the current SDPL model is that i-SDPL emphasises the active involvement of students in designing and implementing industry-relevant projects [6, 7]. In this model, students not only learn about theoretical concepts, but also apply their knowledge in real situations. Thus, students can develop technical skills and soft skills that are highly needed in the world of work [1, 8]. One of the advantages of i-SDPL is its ability to provide a more in-depth and contextualised learning experience for students. In their self-designed projects, students have to interact with various stakeholders, including teachers, industry professionals and peers (9,10). These interactions not only enrich their learning experience, but also help students build professional networks that can be useful

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in the future. In addition, students also learn to work in teams, resolve conflicts, and manage time effectively.

Integration with industry in SDPL provides opportunities for students to access the latest technology and practical knowledge that is not always available in an academic environment [11, 12]. Through collaboration with industry, students can keep up with the latest trends, understand market needs, and prepare themselves for upcoming challenges [13, 14]. This is especially important given the rapid changes in technology and the need for a flexible and adaptive workforce. Industry also benefits by being involved in the education process, such as identifying potential workforce candidates and contributing to the development of relevant curricula.

The perceptions of stakeholders, including students, teachers and industry, will be the main focus in assessing the success of this learning model. Students are expected to provide feedback on their learning experience, mastery of technical and soft skills, and the relevance of the project to industry needs. Teachers will provide perspectives on implementation challenges, benefits for improving the quality of learning, and the impact on teaching methods applied in the classroom. Meanwhile, the industry will assess students' work readiness, identify skills gaps, and provide recommendations to enhance the integration of SDPL with evolving industry demands.

In addition, this research will also assess how SDPL can be adapted and implemented in different contexts. Given the diversity of VHSs in Indonesia, it is important to understand the factors that may influence the successful implementation of this model, such as support from school management, availability of resources, and linkages with industry. This study will explore various strategies that can be used to overcome these challenges, as well as evaluate how this model can be integrated with existing educational programs.

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With the growing need for a ready and competent workforce, it is important to evaluate and update existing learning approaches. Industry-integrated SDPL (i+SDPL) offers an attractive model to improve the work readiness of vocational students [15]. The i-SDPL model emphasises student independence in designing and implementing industry-based projects, with direct integration in every stage of learning to improve work readiness. Its advantages lie in active industry involvement, real product-based learning, and holistic strengthening of technical competence and soft skills compared to conventional methods.

The performance of the i+SDPL model is measured based on three main competency aspects with clear indicators and criteria: (a). Attitude. Assessed through rigour, teamwork, hard work and discipline, as well as creativity and innovation, which reflect students' readiness in a real work environment. (b) Knowledge. Measured based on technical understanding and material knowledge required by the industry, ensuring students master the theory and its application. (c) Skills. Covers mechanical and information technology skills, which form the basis of industrial practice and the use of modern technology [16, 17].

Overall, this research aims to provide a comprehensive insight into the development of an industry-integrated Self-Design Project Learning Model in SMK. By examining various aspects of this model, it is hoped that ways can be found to improve its effectiveness and provide maximum benefits for students. The results of this research are not only relevant for VHSs in Indonesia, but can also serve as a reference for vocational education institutions in other countries facing similar challenges.

Literature Review

Vocational High Schools (VHS) serve as educational institutions designed to prepare graduates for immediate entry into the workforce in their respective

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fields of expertise [18, 19]. VHS play a crucial role in meeting the labor demands of various industrial sectors. Consequently, the quality of VHS graduates directly impacts industrial productivity. Well-prepared VHS graduates can seamlessly transition into the workforce, contributing effectively to their respective industries and enhancing overall productivity [15, 20].

However, data from the Central Bureau of Statistics indicate that VHS graduates constitute the highest proportion of unemployed individuals, accounting for 9.6% of the total unemployment rate [21]. This high unemployment rate among VHS graduates can be attributed to several factors, with the primary issue being their level of job readiness [22]. Many graduates lack the necessary skills and practical experience demanded by employers, leading to a significant gap between education and employment. Addressing this issue requires a comprehensive approach to improve the vocational training curriculum, incorporate industry-specific skills, and provide real-world experience to enhance the employability of VHS graduates [23, 24].

The readiness to enter the workforce among graduates of VHS is formed through a comprehensive learning process that includes theoretical instruction, practical training, and industry exposure [25]. Vocational high schools have been progressively enhancing the quality of their education by integrating advanced educational methods and updating their curricula to meet the evolving demands of the job market [25, 26]. These efforts encompass a variety of initiatives, including the adoption of modern teaching techniques, the improvement of learning facilities, and the use of technology-enhanced learning tools. Despite these advancements, the issue of high unemployment rates among VHS graduates remains a significant challenge, requiring further strategic interventions.

A critical component of addressing this challenge is the establishment of robust partnerships between vocational high schools and industries [27]. Such

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collaborations are essential for aligning the educational outcomes of VHS students with the specific skills, knowledge, and attitudes required by employers [28]. By engaging directly with industries, vocational schools can ensure that their curricula are not only relevant but also forward-looking, preparing students for current and future job market demands [29, 30]. These partnerships facilitate the exchange of valuable insights and allow for the adaptation of teaching methodologies to better meet industry standards. Moreover, industry involvement in the education process can provide students with practical experience and real-world exposure, further enhancing their readiness for employment [31, 32].

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To effectively implement these industry-school collaborations, a systematic approach is required [33, 34]. This includes conducting comprehensive needs analyses to identify the specific competencies demanded by various sectors, developing detailed task descriptions that outline the expected job roles, and establishing clear competency standards that serve as benchmarks for student performance. Additionally, creating rigorous assessment procedures is crucial for evaluating whether students have acquired the necessary skills and knowledge. These assessments should be designed in consultation with industry experts to ensure their relevance and accuracy. Through these collaborative efforts, vocational high schools can produce graduates who are not only academically proficient but also possess the practical capabilities and professional attitudes required to thrive in the workforce [35, 36].

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The pivotal factor contributing to the effective cultivation of work readiness among graduates of VHS resides in the proactive engagement of the industry in establishing competency benchmarks for VHS graduates, encompassing attitudes, knowledge, and skills [37, 38, 39]. The main criterion for the implementation of VHS is the formation of competencies with

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standardization in accordance with the needs of the world of work. A pedagogical methodology garnering increasing attention in vocational education is Self-Design Project Learning (SDPL) [40]. SDPL stands out as a pedagogical model deemed suitable for adoption within vocational education settings. The fundamental aim of the SDPL framework is to align the caliber of vocational graduates with industry exigencies [41, 42]. SDPL is characterized by students acquiring proficiency in attitude, knowledge, and work skills through their engagement with products or projects. The SDPL framework comprises seven distinct stages, namely: (a) Product/Project Planning; (b) Implementation; (c) Inquiry and Development; (d) Collaboration; (e) Evaluation; (f) Presentation; and (g) Reflection [43, 44, 45, 46].

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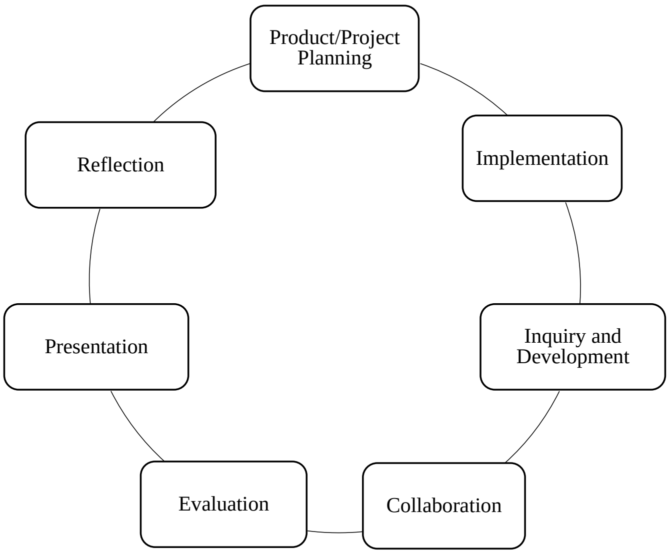

Fig. 1. Stages of the Self Design Project Learning (SDPL) Model

The i-SDPL (Integrated Project-Based Learning) model represents a refinement of traditional Project-Based Learning (PjBL), aimed at addressing the inherent limitations observed in the standard SDPL approach. Recent scholarly investigations, as documented by Hariyanto et al. (2023), Nilsook et al. (2021), and R. Zhang et al. (2023), have underscored deficiencies primarily pertaining to collaborative dynamics and the degree of industrial engagement within the educational milieu. These shortcomings have prompted a concerted effort to reconceptualize the SDPL framework, thereby fostering a more symbiotic relationship between academia and industry [47, 48, 49].

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The integration of i-SDPL with industrial imperatives is multifaceted, encompassing several key facets. Firstly, it necessitates the alignment of educational objectives with the dynamic demands of contemporary industries. This alignment ensures that curricular content is not only relevant but also responsive to the evolving needs of the professional landscape. Secondly, the collaborative partnership between educators and industry stakeholders assumes paramount significance. By fostering close ties between these two spheres, i-SDPL endeavors to bridge the gap between theoretical knowledge and practical application, thereby imbuing students with a holistic understanding of their chosen vocation. Finally, the utilization of industrial infrastructure serves to immerse students in an authentic work environment, thereby providing firsthand exposure to the challenges and nuances of their respective industries.

Ultimately, the overarching goal of integrating the i-SDPL model with industry is to enhance the vocational preparedness of students enrolled in Vocational High Schools (VHS) while simultaneously mitigating the incidence of post-graduation unemployment. Through a synergistic blend of academic rigor and real-world applicability, i-SDPL seeks to empower students with the requisite skills and competencies to thrive in an increasingly competitive job market. Moreover, by fostering a culture of collaboration and partnership between academia and industry, i-SDPL not only serves the immediate interests of students but also contributes to the broader socio-economic development of the communities it serves [50, 51, 52, 53].

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Methodology, Materials and Methods

This study employed Richey and Klein's research and development design, comprising three distinct stages of inquiry. The stages of the research and development of the Integrated industry Self-Design Project Learning model are divided into 3 stages. These stages are needs analysis, internal validation and external validation. The needs analysis stage aims to explore information about the condition of learning in VHS, what aspects of competence are needed by the industry and VHS and what materials are currently needed by the industry and can be integrated with a product / project-based learning model. This stage involves 10 teachers and 12 industry practitioners to ensure that learning needs are accurately identified and aligned with industry requirements.

The Internal Validation stage aims to obtain feedback from experts to ensure that the learning model and Practical Performance Test instruments are suitable for application in the External Validation stage. This stage involves 2 vocational education experts and 2 industry practitioners who assess the feasibility of the developed models and instruments. Their input is used to refine and adjust the models before wider testing. The External Validation stage focuses on evaluating the effectiveness of the learning model in enhancing students' work readiness. This process involves a series of tests and trials, beginning with a pretest involving 32 students, followed by a limited test with 20 students, and culminating in a broader trial with 136 students. This phased approach allows for a thorough evaluation of the learning model, from small groups to larger cohorts, ensuring its effectiveness and reliability in an educational setting.The sequential progression of these research stages is illustrated in Figure 2.

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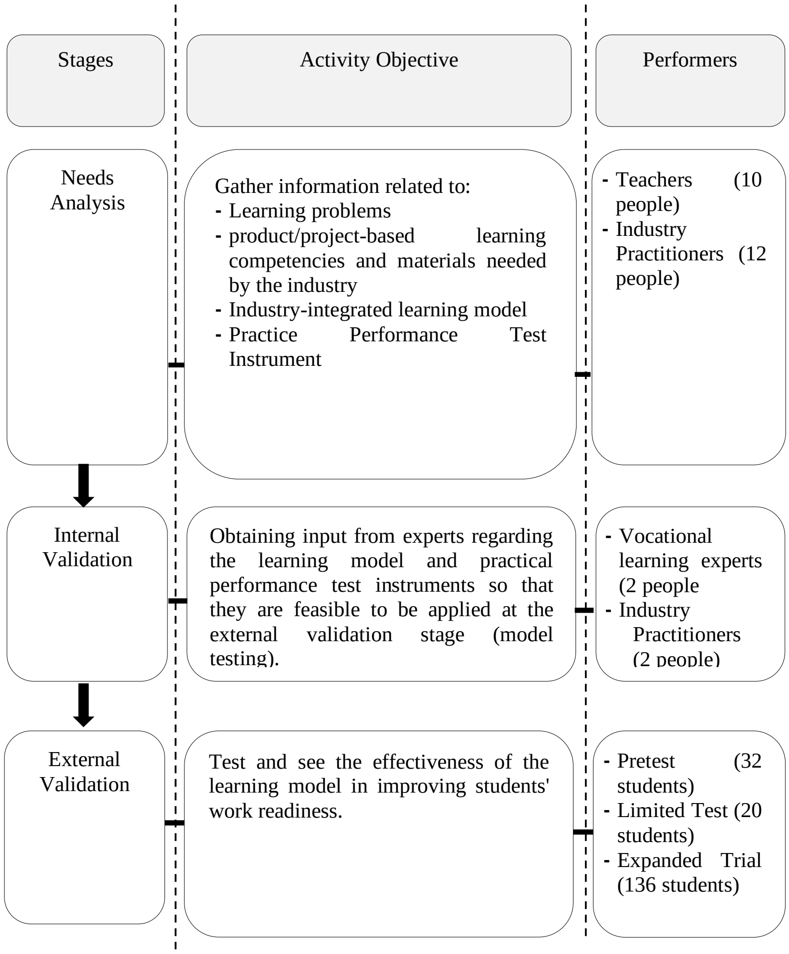

Fig. 2. Research and Development Procedures

The data collection methodologies employed in this study encompassed both test-based and non-test-based approaches. Non-test methodologies comprised interviews and questionnaires. The test-based methodology entailed a practical performance examination. Interviews were conducted through focused group discussions to glean insights into learning impediments, competencies, and the requisite product/project-oriented learning materials essential for industry integration.

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Table 1

The internal validation instrument grids

No	Criteria	Assessment Indicators
1	Relevance	The learning model is relevant to the learning objectives to be achieved
2		The learning model is appropriate to the needs and characteristics of students.
3	Clarity	The instructions and steps in the learning model are clearly presented and easy to understand.
4	Readability	The language used in the learning model is easy to understand by students, teachers and industry practitioners.
5	Applicability	The learning model can be applied in the context of classroom learning
6	Effectiveness	The learning model is effective in improving aspects of student competence
7	Suitability to the Curriculum	The learning model is in accordance with the applicable curriculum and is able to support the achievement of basic competencies that have been determined
8	Industry participation	The learning model encourages industry participation

To see the feasibility of the learning model and practical performance assessment instruments, validation and input from experts consisting of vocational education/learning experts and industry practitioners are required. Furthermore, the learning model and practical performance assessment instruments resulting from internal validation are applied to the external validation stage to determine the effectiveness of the learning model in improving students' work readiness. The internal validation instrument grids for experts and learning evaluation instruments can be seen in Table 1 and Table 2, respectively.

Table 2

Learning evaluation instruments

Competencies	Competency Aspect
Attitude	Thoroughness
	Teamwork
	Hard Work and Discipline
	Creativity and Innovation
Knowledge	Technical Knowledge
	Material Knowledge
Skills	Mechanical Skills
	Information Technology Skills

The validity and reliability of the interview, questionnaire, and performance test instruments were assessed through rigorous content validity tests conducted by experts drawn from the realms of vocational learning and industry. Specifically, these experts held positions as car service advisors, ensuring a specialized understanding of the subject matter. Reliability testing, on the other hand, was executed utilizing the Cronbach Alpha (α) test, a renowned measure known for its ability to ascertain internal consistency reliably. The outcomes consistently affirmed the instruments' reliability. The assessment instrument for the student practical performance test underwent meticulous development, spearheaded by VHS Automotive Engineering educators, automotive industry practitioners, and vocational learning authorities. Drawing upon the seminal research titled 'Development of an Industry-Oriented Experiential Learning (EL+i) Model to Enhance Vocational High School Students' Job Readiness', as delineated in Table 3, the instrument was tailored to suit the exigencies of the study.

Table 3

Categorization Of Questionnaires and Practical Performance Tests

Score	Category
3.01 - 4.00	Very Effective
2.51 - 3.00	Effective
2.01 - 2.50	Less effective
0 - 2.00	Ineffective

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Quantitative data analysis served as the cornerstone for evaluating both the model's feasibility questionnaire instrument and the practical performance assessment instrument, alongside the subsequent analysis of the practical performance test results. This analytical approach facilitated comprehensive categorization and interpretation of the amassed data.

Research Results

Needs Analysis

The needs analysis stage aims to investigate learning challenges, required competencies, and the product or project-based learning materials necessary for industry integration. Data analysis was conducted through focus group discussions involving participants from vocational high school automotive engineering teachers and automotive industry practitioners. The findings from the needs analysis stage are presented in Table 4, Table 5, and Figure 3. The results indicate that the current industry demands product and project-based learning materials, specifically in the areas of electric vehicle modification, gas and electric welding, and oven painting.

Table 4

Learning problems

No	Indicators	Vocational School Teachers	Industry Practitioners
1.	Learning Planning	Teachers plan lessons in accordance with the instructions of related agencies; there is no role for	VHSs do not collaborate with industry in lesson planning.

		industry.	
2.	Learning Implementation	During this time, the implementation of learning is done by teachers themselves; the role of industry is absent.	VHSs passively collaborate and cooperate with industry in the implementation of learning.
3.	Evaluation of Learning	VHS-based evaluation; no industry role.	VHS collaboration with industry is limited to graduation competency tests. Not implemented on every competency indicator required by VHS.
4.	Graduate Quality	The quality of graduates is not certified by the industry.	The quality of graduates depends on the results of the VHS process, while industry contributes minimally.

The analysis reveals significant deficiencies in the collaboration between vocational high schools and industry in planning, implementation, evaluation, and graduate quality. The curriculum is developed and implemented unilaterally by vocational high schools without industry participation. Thus, industry involvement is lacking. Evaluation is primarily managed by vocational high schools, with industry participation limited to graduation competency tests, resulting in graduates lacking industry certification. To address these issues, it is recommended to establish partnerships between vocational high schools and industry to co-develop curricula that integrate current industry standards and practices.

Industry professionals should actively participate in teaching and provide practical training, while continuous evaluation involving industry practitioners should be implemented to ensure students meet the required competencies. In addition, certification processes developed in collaboration with industry should validate graduates' skills and knowledge, thereby improving their employability and ensuring vocational education is aligned with current industry standards.

Industry practitioners work together with vocational high schools to play an active role in the planning, implementation, evaluation, certification and sustainability of vocational high school graduates to form competency completeness that meets industry criteria.

Table 5

Competencies required by industry

Competencies	Competency Aspect	Description
Attitude	Thoroughness	Ability to perform work with detail and accuracy.
	Teamwork	Ability to work with others in a team, collaborate and support each other to achieve common goals.
	Hard Work and Discipline	Ability to complete tasks in a timely manner and to a high standard of quality.
	Creativity and Innovation	Ability to think beyond predictions, seek new solutions, or improve existing processes.
Knowledge	Technical Knowledge	Ability about the principles, concepts, and specific details of a field of technology or science.
	Material Knowledge	Understanding of the types of materials, their properties, processing methods and applications in technology, their properties, optimal use, and ways of processing and application in various contexts.
Skills	Mechanical Skills	Skills in maintenance and repair of work equipment and field of work.
	Information Technology Skills	Skills in using software and related technology that supports work processes in industry.

The listed competencies are comprehensive and encompass essential areas for vocational students, particularly those specializing in electric vehicles. Attitude-related competencies prepare students to work effectively and innovate within teams. Knowledge-based competencies provide the theoretical foundation necessary for understanding and applying technical concepts. Skill-related competencies ensure students can perform practical tasks and utilize modern technologies proficiently. Integrating these competencies into vocational education can significantly enhance students' readiness for the workforce, especially in technical and rapidly advancing fields such as electric vehicle technology.

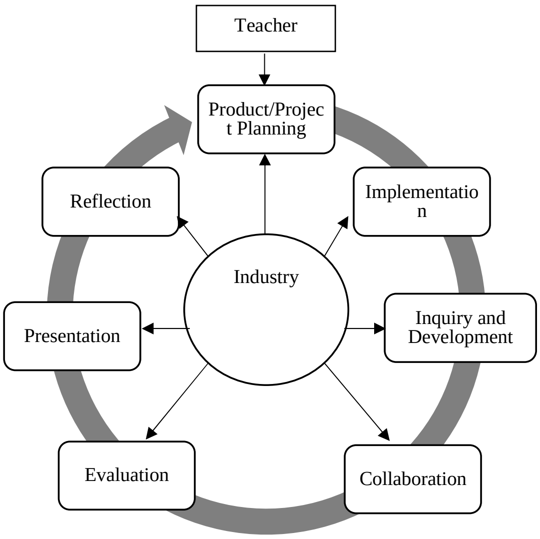


Fig. 3. SDPL Learning Model from Needs Analysis (Conceptual)

Internal Validation

The internal validation stage aims to determine feasibility and seek input and suggestions from experts regarding the feasibility of practical performance assessment models and instruments, which will be applied at the external validation (trial) stage. Experts involved in the internal validation stage include: (a) vocational learning lecturers with over 15 years of academic experience, automotive competency certificates, and relevant work in automotive engineering, and (b) industry practitioners with over 10 years of experience as service advisors or workshop heads.The results of the internal validation indicate that the practical performance assessment instrument aligns with the measured competencies, rubric criteria, and scoring.

Regarding the industry-integrated i+SDPL learning model, the following are key points generated from the internal validation stage: (a) i+SDPL emphasizes collaboration between industry and educators at every stage of the model. (b) Implementation of the model is feasible in both vocational schools and industry, taking into account the availability of learning facilities and infrastructure. (c) Evaluation occurs in the industry with graduation standards aligned with industry needs. The revised i+SDPL learning model, incorporating feedback from the internal validation stage, is illustrated in Figure 4.

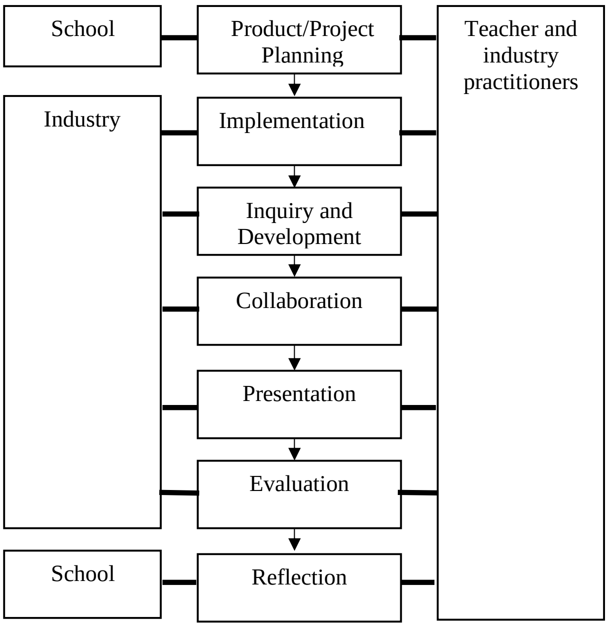


Fig. 4. Used Industry Integrated Self Design Project Learning Model (i+SDPL)

The i+SDPL model contains stages that aim to shape the work readiness of the rest of the vocational school. (a) Product/project planning contains activities aimed at establishing clear learning objectives, selecting appropriate projects/products, and scheduling their implementation. (b) The implementation stage contains student activities in implementing learning in accordance with the learning plan. Teachers and industry practitioners ensure learning outcomes comply with industry standards. This phase is important for grounding theoretical knowledge in practical application.

(c) The investigation and development stage encourages students to complete learning tasks according to the knowledge and skills they have acquired. (d) The collaboration stage is the stage where students interact directly with industry practitioners to gain experience, knowledge and skills according to the needs of the industrial world. (e) The presentation stage contains activities to demonstrate the results of the problem solving process/tasks that have been studied. Here communication will be formed and produce input from other students, teachers and industry practitioners. (f) The evaluation stage contains competency tests and feedback that are in line with industry standards. (g) The final stage, reflection, allows teachers and industry practitioners to assess learning outcomes and develop further strategies for developing student competencies.

Table 4

Stages of Industry Integrated Self Design Project Learning Model (i+SDPL)

Model Stages	Activities	Time
Product/Project Planning	Industry Practitioner and Teacher together:	Before learning
	Determine learning objectives	
	Determine the project or product that will be used for learning	
	Inform students about the work plan and schedule for learning implementation	
	Divide the group	
Implementation	Students start practicing and working according to the projects planned by teachers and industry practitioners	According to industry standards
	Industry Practitioners and Teachers together provide guidance to students when needed	
Inquiry and Development	Students complete a project/product	
	Apply the attitudes, knowledge and skills gained from learning	

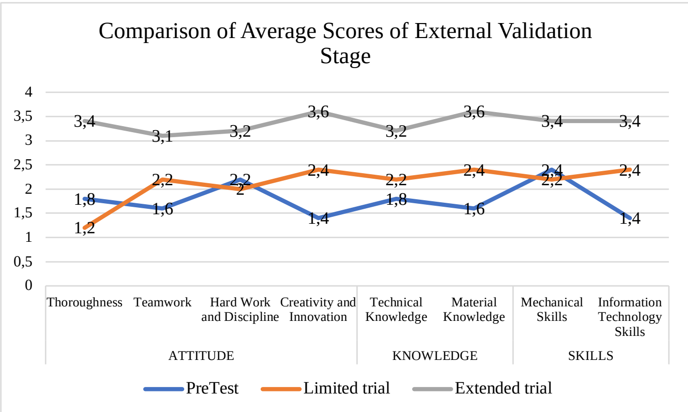
	Industry Practitioners and Teachers together provide guidance to students when needed	
Collaboration	Students interact with industry practitioners who are experienced in completing projects / products	
Presentation	Students present the results of the project / product that is done	10 minutes/group
Evaluation	Teachers and industry practitioners evaluate student progress on a regular basis	As per industry standard
	Teachers or industry practitioners conduct competency tests	
	Teachers and industry practitioners summarize and provide feedback to students	
Reflection	Teachers and industry practitioners reflect on learning outcomes and plan steps for student competency development.	At the end of the lesson

External Validation

The external validation stage is divided into two: limited trial and extended trial stages. The purpose of external validation is to determine the effectiveness of the i+SDPL model in improving the work readiness of vocational students. External validation activities began with a pretest involving 32 students of VHS Muhammadiyah 2 Tempel. The subject matter tested was welding with a motorcycle chain cover project. The limited trial was conducted at VHS Muhammadiyah 1 Salam Magelang involving 20 students who studied welding with a toolbox project. Meanwhile, the extended trial was conducted at SMK Muhammadiyah 1 Salam and SMK Muhammadiyah Pakem, involving 136 students from the Automotive Engineering Department.

The analysis of the table indicates significant improvements across various categories attitude, knowledge, and skills from pretest to posttest. In the attitude category, there was a notable increase in creativity and innovation, with scores rising from 1.4 in the pretest to 3.6 in the posttest. Although some categories, such as conscientiousness and hard work and discipline, experienced a decline during the trials stage, both showed significant improvement in the posttest. The knowledge category also demonstrated a positive upward trend, with material knowledge increasing from 1.6 in the pretest to 3.6 in the posttest. Similarly, the skills category exhibited growth, with information technology skills improving from 1.4 in the pretest to 3.4 in the posttest.

Overall, these results suggest that the implemented program or intervention was successful in enhancing participants' attitudes, knowledge, and skills, despite some fluctuations during the trials stage. This indicates that, despite initial challenges, participants were able to overcome and significantly improve their abilities through the learning process or intervention conducted. The results of the external validation stage can be seen in Figure 5.



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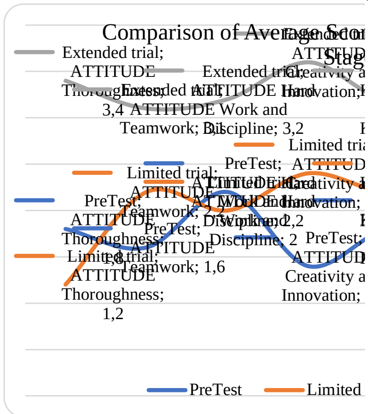

Fig. 5. Comparison of Average Scores of External Validation Stage

Сравнение средних баллов на этапе внешней валидации

Results and Discussion

The Industry Integrated Self Design Project Learning (i+SDPL) Model, derived from the Project-Based Learning (PjBL) framework, emphasizes the development of student competencies through direct engagement with industry-related projects and products [45, 55, 56]. This model integrates theoretical and practical learning, fostering a holistic development of attitudes, knowledge, and

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skills. Key characteristics of the i+SDPL model include its collaborative approach, where educators and industry practitioners work together to guide students. The curriculum is aligned with industry standards, ensuring that the competencies students acquire are relevant and up-to-date with current industrial demands. Furthermore, the model includes rigorous stages of implementation and evaluation, conducted within industrial settings, which immerse students in real-world work environments. This not only bridges the gap between classroom learning and industry practice but also facilitates a smoother transition for students into the workforce.

In the i+SDPL learning model, the integration of project- and product-based learning with industry standards is pivotal in shaping student competencies to meet industry needs. By working on real-life industry projects, students gain practical experience and develop skills that are directly applicable in their future careers. This experiential learning approach not only enhances technical proficiency but also fosters critical thinking, problem-solving, and collaboration skills. Exposure to the industrial climate plays a crucial role in preparing students for professional environments by enhancing their understanding of industrial processes and work culture. This comprehensive exposure helps in developing the character and work readiness of vocational high school (VHS) students, making them more adaptable and capable of meeting the challenges of the modern industrial landscape [57, 58, 59]. The i+SDPL model, therefore, represents a significant advancement in vocational education by ensuring that students are not only academically proficient but also industry-ready.

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The i+SDPL learning model has been demonstrated to be highly effective in enhancing work readiness across various dimensions, including attitudes, knowledge, and skills. This model significantly improves competence in the attitude of accuracy. Project-based learning, a core component of the i+SDPL model, emphasizes the final product's quality. To achieve a high-quality product, students must meticulously attend to every detail and ensure that each step is executed carefully, thereby consistently developing a thoroughness attitude [60, 61]. Additionally, the i+SDPL learning model is an effective method for fostering competence in teamwork attitudes. Student collaboration/cooperation in producing products/projects forms students' competence in discussing and providing different knowledge [62, 63].

The competency of hard work and discipline refers to a person's ability to complete tasks on time with high quality standards. Through the application of the i+SDPL learning model by producing projects or products, students can create work that meets industry standards, which emphasize completeness, efficiency and perfection. With the consistent application of i+SDPL, an optimal attitude of hard work and discipline will be formed [64, 65, 66]. The next attitude competency is creativity and innovation. The application of i+SDPL will strengthen students' creativity and innovation attitude. In the process of making products, students repeatedly receive feedback/direction from industry practitioners and teachers. The process encourages students to always innovate, looking for new ways to improve the quality of the products they produce, so that their competencies in creativity and innovation develop progressively [67, 68, 69].

Motivational factors for all participants in the i+SDPL model include aspects from students, teachers, and industries involved in the learning process. The i+SDPL learning model stimulates students to understand and apply concepts and theories in product manufacturing. Through the i+SDPL learning model, students more easily understand the relevance and importance of technical knowledge in practical applications. Not only that, but this model also facilitates students to directly experience the process and challenges of completing a project or product. These activities encourage students to develop

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technical skills from planning, implementation, to evaluation [70, 71]. Furthermore, the i+SDPL learning model enhances students' material knowledge competency. The industry-integrated approach of i+SDPL emphasizes that application in completing projects or products will shape students' attitudes, knowledge and work skills. Students can observe how material theories and concepts are applied in real situations of making projects or products. The industry-based product-based learning model provides a deep understanding of the use and processing of materials in a practical context [72, 73, 74].

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For teachers, motivation comes from their role as facilitators who not only teach theory but also guide students in industry-based projects. This model allows teachers to update their insights through co-operation with industry as well as develop more innovative and effective learning methods. In addition, students' success in producing quality projects is a source of satisfaction for educators.

For the industry, involvement in SDPL is an opportunity to get a more prepared and skilled workforce candidate according to the company's needs. By participating in the design and evaluation of projects, industries can ensure that graduates have competencies that meet their standards. In addition, this model also helps the industry to build close relationships with educational institutions, which can lead to wider cooperation in the future.

Mechanical skills competency refers to a person's practical ability to understand, maintain, repair and operate equipment and machine components. The i+SDPL learning model is developed in accordance with industry needs and standardization. Through the application of the model, students get the opportunity to apply mechanical theories and concepts in making projects or products. Working according to industry standards, students are able to understand how mechanical principles apply in a real industrial context [75, 76, 77, 78]. The project-based learning model integrated with industry can improve the competence of information technology skills. Through the completion of industry-standard projects or products, students have the opportunity to interact with a variety of tools, platforms and information technologies commonly used in the industrial world [78, 79, 80, 81]. These learning activities equip students with practical and technical skills in operating, maintaining and utilizing various solutions using information technology [82, 83].

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The i+SDPL model has several limitations that can affect its effectiveness. One of the main challenges is the limited collaboration with industry, especially for schools that do not have easy access to relevant companies. This can be overcome by building a wider network of partnerships through internship programmes, curriculum cooperation and industry visits. In addition, limited resources and infrastructure in some schools are also an obstacle in implementing this model. Solutions that can be applied are the utilisation of simulation technology, cooperation with companies for access to industrial facilities, and procurement of equipment through educational grants.

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On the other hand, students' level of independence in learning varies, which can affect the smooth running of their projects. To overcome this, initial training on project management, more intensive guidance from teachers and industry mentors, and periodic evaluations are needed to ensure students' progress. In addition, the evaluation of competency standards is also a challenge due to differences in industry standards that may affect the objectivity of the assessment. Therefore, the development of a standardised assessment rubric with the industry is a solution to ensure a more accurate evaluation and in accordance with the needs of the world of work. An explanation of these limitations and their solutions can be included in the Discussion section to provide insight into the challenges of i+SDPL implementation and strategies to improve its effectiveness.

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Conclusion

The i+SDPL learning model is an innovative approach derived from the Project-Based Learning (PjBL) framework. This model's development stems from a comprehensive needs analysis and feedback from industry experts and practitioners. The distinguishing feature of the i+SDPL model is the integration of industry involvement at every stage of the learning process, including preparation, implementation, and evaluation. Moreover, the i+SDPL model is executed in a blended format, combining learning experiences in vocational high schools (VHS) and industry settings. The industry component is designed to acquaint students with the professional work environment at an early stage.

The i+SDPL learning model has demonstrated its efficacy in enhancing competencies in attitude, knowledge, and work skills through two trial implementations. The model's application is intended to benefit not only students but also teachers. For educators, the i+SDPL model serves as a mechanism to update and expand their knowledge in line with current industry advancements.

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B. Sudarsono - research conceptualisation, research methodology, validation of methodology procedures, writing original draft.
W.N.E. Saputra - research methodology, validation of methodology procedures, job readiness instrument, writing a final draft, text editing.
F.A. Ghozali - data analysis, writing a final draft, text editing.

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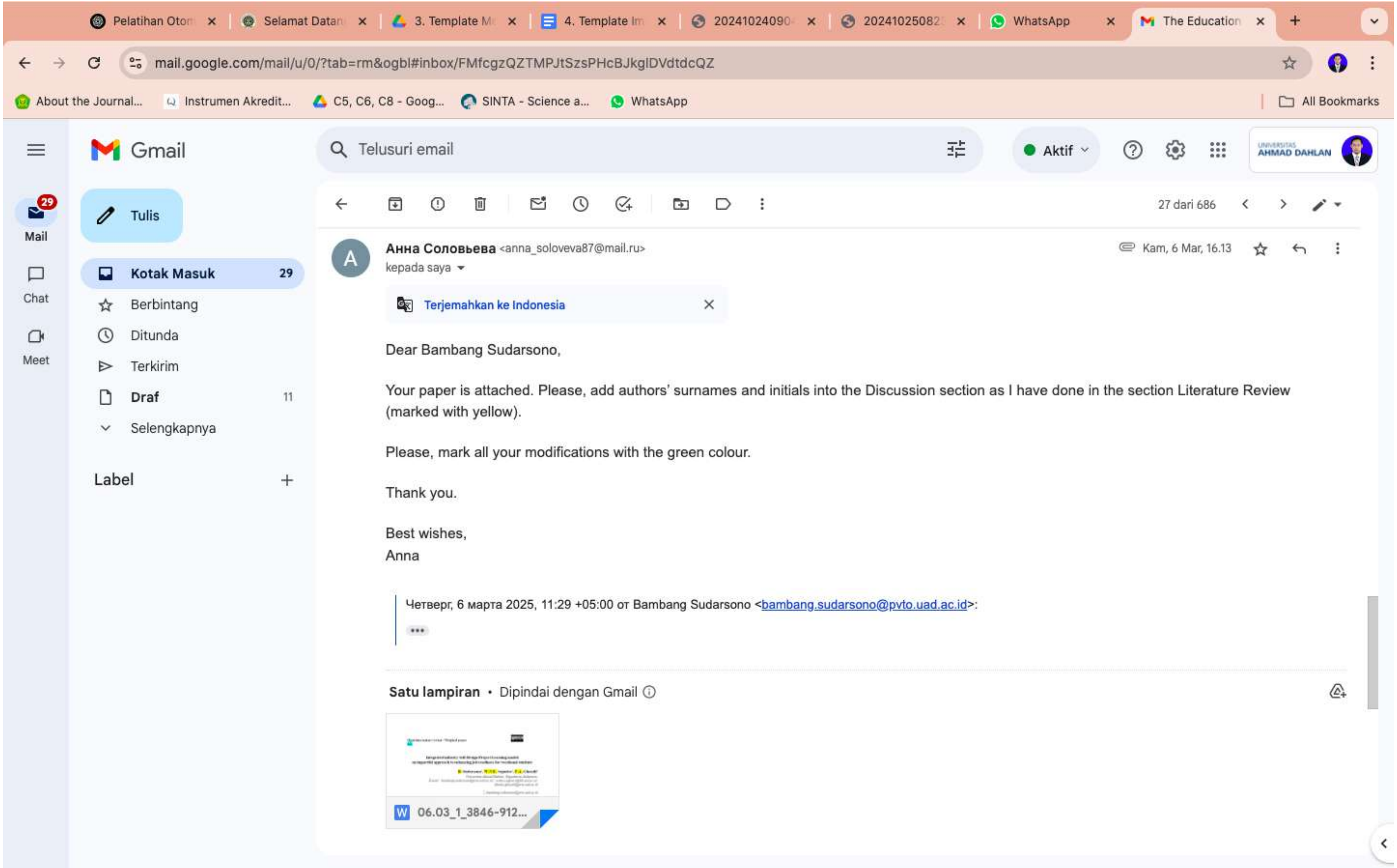

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Thank you.

Best wishes,
Anna

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kepada Анна

Warm greetings from Indonesia
Prof Anna, I have revised the article and submitted it. if there is anything that needs to be revised, I am ready to revise it again if there is a revision.
Thank you

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HASIL CATATAN DAN PERBAIKAN ROUND 2

Round 2 (3 Maret 2025)			
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1	an impactful approach to enhancing job readiness for vocational students – Do you agree to change the second part of the title?	Integrated industry Self-Design Project Learning model: an impactful approach to enhancing job readiness for vocational students	1
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HASIL ARTIKEL YANG DIPERBAIKI
ROUND 2

Оригинальная статья / Original paper
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Integrated industry Self-Design Project Learning model: an impactful approach to enhancing job readiness for vocational students

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Abstract. Introduction. In 2023, graduates of Vocational High Schools (VHS) in Indonesia are still one of the highest contributors to the unemployment rate. This continuing problem is caused by the inadequate work readiness of VHS students. The main problem lies in the current educational approach which is still limited to vocational schools and less integrated with industry needs. *Aim*. The purpose of this study is to develop a product-based learning model that is aligned with industry needs and evaluate its effectiveness in improving the work readiness of vocational students. *Methodology and research methods.* This research was carried out in the stages of needs analysis, internal validation, and external validation. Data collection techniques consisted of test and non-test methods, using instruments such as interviews, questionnaires, and practical performance tests. *Results and scientific novelty*. The collected data were analysed descriptively and the results were interpreted using categorisation criteria. The findings show that the industry-integrated Self-Design Project Learning (i-SDPL) learning model and performance test measurement tools are very effective in the context of vocational education. Specifically, the i-SDPL learning model significantly enhanced students' work readiness, with average scores of 3.3 for attitude competency and 3.4 for both knowledge and skill competencies. The scientific novelty of the Self-Design Project Learning (SDPL) learning model lies in the integration of industry needs that enable students to develop competencies. Students are designed to carry out projects independently, thus fostering a deeper understanding of industry-relevant skills and knowledge. *Practical significance*. The implementation of the i-SDPL model is expected to encourage greater industry recognition of the competencies developed by VHS graduates and further strengthen the partnership pattern between VHS and industry.

Keywords: integrated industry, self-design project learning (i-SDPL), vocational students, job readiness

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Интегрированная модель обучения в рамках отраслевого проекта по самостоятельному проектированию: эффективная модель обучения для готовности студентов к работе

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Аннотация. *Введение.* В 2023 году выпускники профессионально-технических училищ (VHS) в Индонезии по-прежнему являются одним из самых высоких источников безработицы. Эта сохраняющаяся проблема вызвана недостаточной готовностью студентов VHS к работе. Основная проблема заключается в нынешнем образовательном подходе, который по-прежнему ограничен профессиональными учебными заведениями и в меньшей степени интегрирован с потребностями промышленности. *Цель.* Целью данного исследования является разработка модели обучения, основанной на продукте, которая соответствует потребностям отрасли, и оценка ее эффективности в повышении готовности к работе студентов профессиональных учебных заведений. *Методология и методы исследования.* Данное исследование проводилось на этапах анализа потребностей, внутренней и внешней валидации. Методы сбора данных включали в себя тестовые и непроверенные методы с использованием таких инструментов, как интервью, анкетирование и практические тесты эффективности. *Результаты и научная новизна.* Собранные данные были проанализированы описательно, а результаты интерпретированы с использованием критериев категоризации. Полученные результаты показывают, что модель обучения i-SDPL и инструменты измерения результатов тестов очень эффективны в контексте профессионального образования. В частности, модель обучения i-SDPL значительно повысила готовность студентов к работе: средний балл за отношение к работе составил 3,3 балла, а за знания и навыки - 3,4 балла. *Научная новизна* модели обучения самостоятельному проектированию (SDPL) заключается в интеграции отраслевых потребностей, которые позволяют студентам развивать компетенции. Студенты разрабатываются для самостоятельного выполнения проектов, что способствует более глубокому пониманию навыков и знаний, имеющих отношение к отрасли. *Практическая значимость.* Ожидается, что внедрение модели i-SDPL будет способствовать более широкому признанию отраслью компетенций, приобретенных выпускниками VHS, и дальнейшему укреплению партнерских отношений между VHS и промышленностью.

Ключевые слова: интегрированная индустрия, самостоятельное проектное обучение (i-SDPL), студенты-профессионалы, готовность к работе

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Для цитирования: Сударсоно Б., Сапутра В.Н.Э., Гхозали Ф.А. Интегрированная модель обучения в рамках отраслевого проекта по самостоятельному проектированию: эффективная модель обучения для готовности студентов к работе. *Образование и наука.* 2025;27(6):…–…. doi:

Introduction

The Fourth Industrial Revolution, known as Industry 4.0, has brought about major changes in various sectors, including the world of work. In this era, the skills required are no longer limited to technical abilities, but also include soft skills such as critical thinking, creativity, and the ability to collaborate [1, 2]. Vocational high schools (VHSs) in Indonesia aim to produce a workforce that is competent and ready to face the world of work [3, 4, 5]. Therefore, adjustments are needed in the curriculum, learning methods, and competency standards to suit industry needs. However, there is still a gap between the world of education and the world of work, which causes VHS graduates to not be fully prepared to face challenges in the industry.

The industry-integrated Self-Design Project Learning (i-SDPL) model is emerging as a potential solution to address these challenges. The i-SDPL model is an extension of the existing SDPL model and emphasises the active involvement of students in designing and implementing relevant projects in learning. The main difference with the current SDPL model is that i-SDPL emphasises the active involvement of students in designing and implementing industry-relevant projects [6, 7]. In this model, students not only learn about theoretical concepts, but also apply their knowledge in real situations. Thus, students can develop technical skills and soft skills that are highly needed in the world of work [1, 8]. One of the advantages of i-SDPL is its ability to provide a more in-depth and contextualised learning experience for students. In their self-designed projects, students have to interact with various stakeholders, including

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teachers, industry professionals and peers [9, 10]. These interactions not only enrich their learning experience, but also help students build professional networks that can be useful in the future. In addition, students also learn to work in teams, resolve conflicts, and manage time effectively.

Integration with industry in SDPL provides opportunities for students to access the latest technology and practical knowledge that is not always available in an academic environment [11, 12]. Through collaboration with industry, students can keep up with the latest trends, understand market needs, and prepare themselves for upcoming challenges [13, 14]. This is especially important given the rapid changes in technology and the need for a flexible and adaptive workforce. Industry also benefits by being involved in the education process, such as identifying potential workforce candidates and contributing to the development of relevant curricula.

The perceptions of stakeholders, including students, teachers and industry, will be the main focus in assessing the success of this learning model. Students are expected to provide feedback on their learning experience, mastery of technical and soft skills, and the relevance of the project to industry needs. Teachers will provide perspectives on implementation challenges, benefits for improving the quality of learning, and the impact on teaching methods applied in the classroom. Meanwhile, the industry will assess students' work readiness, identify skills gaps, and provide recommendations to enhance the integration of SDPL with evolving industry demands.

In addition, this research will also assess how SDPL can be adapted and implemented in different contexts. Given the diversity of VHSs in Indonesia, it is important to understand the factors that may influence the successful implementation of this model, such as support from school management, availability of resources, and linkages with industry. This study will explore various strategies that can be used to overcome these challenges, as well as evaluate how this model can be integrated with existing educational programmes.

With the growing need for a ready and competent workforce, it is important to evaluate and update existing learning approaches. Industry-integrated SDPL (i-SDPL) offers an attractive model to improve the work readiness of vocational students [15]. The i-SDPL model emphasises student independence in designing and implementing industry-based projects, with direct integration in every stage of learning to improve work readiness. Its advantages lie in active industry involvement, real product-based learning, and holistic strengthening of technical competence and soft skills compared to conventional methods.

The performance of the i-SDPL model is evaluated based on three primary competency aspects, each with clear indicators and criteria: (a) Attitude. This is assessed through rigour, teamwork, diligence, discipline, as well as creativity and innovation, which reflect students' preparedness for a real work environment. (b) Knowledge. This is measured by the technical understanding and material knowledge required by the industry, ensuring that students master both the theory and its practical applications. (c) Skills. This encompasses mechanical and information technology skills, which are fundamental to industrial practice and the utilisation of modern technology [16, 17].

Overall, this research aims to provide a comprehensive insight into the development of an industry-integrated Self-Design Project Learning Model in VHS. By examining various aspects of this model, it is hoped that ways can be found to improve its effectiveness and provide maximum benefits for students. The results of this research are not only relevant for VHSs in Indonesia, but can also serve as a reference for vocational education institutions in other countries facing similar challenges.

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Literature Review

Vocational High Schools (VHS) serve as educational institutions designed to prepare graduates for immediate entry into the workforce in their respective fields of expertise [18, 19]. VHS play a crucial role in meeting the labor demands of various industrial sectors. Consequently, the quality of VHS graduates directly impacts industrial productivity. According to A. Subhani et.al and S. Tumanduk et al., well-prepared VHS graduates can seamlessly transition into the workforce, contributing effectively to their respective industries and enhancing overall productivity [15, 20].

However, data from the Central Bureau of Statistics indicate that VHS graduates constitute the highest proportion of unemployed individuals, accounting for 9.6% of the total unemployment rate [21]. This high unemployment rate among VHS graduates can be attributed to several factors, with the primary issue being their level of job readiness [22]. Many graduates lack the necessary skills and practical experience demanded by employers, leading to a significant gap between education and employment. Addressing this issue requires a comprehensive approach to improve the vocational training curriculum, incorporate industry-specific skills, and provide real-world experience to enhance the employability of VHS graduates [23, 24].

The readiness to enter the workforce among graduates of VHS is formed through a comprehensive learning process that includes theoretical instruction, practical training, and industry exposure [25]. Vocational high schools have been progressively enhancing the quality of their education by integrating advanced educational methods and updating their curricula to meet the evolving demands of the job market [25, 26]. These efforts encompass a variety of initiatives, including the adoption of modern teaching techniques, the improvement of learning facilities, and the use of technology-enhanced learning tools. Despite these advancements, the issue of high unemployment rates among

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VHS graduates remains a significant challenge, requiring further strategic interventions.

A critical component of addressing this challenge is the establishment of robust partnerships between vocational high schools and industries [27]. Such collaborations are essential for aligning the educational outcomes of VHS students with the specific skills, knowledge, and attitudes required by employers [28]. By engaging directly with industries, vocational schools can ensure that their curricula are not only relevant but also forward-looking, preparing students for current and future job market demands [29, 30]. These partnerships facilitate the exchange of valuable insights and allow for the adaptation of teaching methodologies to better meet industry standards. Moreover, industry involvement in the education process can provide students with practical experience and real-world exposure, further enhancing their readiness for employment [31, 32].

To effectively implement these industry-school collaborations, a systematic approach is required [33, 34]. This includes conducting comprehensive needs analyses to identify the specific competencies demanded by various sectors, developing detailed task descriptions that outline the expected job roles, and establishing clear competency standards that serve as benchmarks for student performance. Additionally, creating rigorous assessment procedures is crucial for evaluating whether students have acquired the necessary skills and knowledge. These assessments should be designed in consultation with industry experts to ensure their relevance and accuracy. Through these collaborative efforts, vocational high schools can produce graduates who are not only academically proficient but also possess the practical capabilities and professional attitudes required to thrive in the workforce [35, 36].

The pivotal factor contributing to the effective cultivation of work readiness among graduates of VHS resides in the proactive engagement of the industry in establishing competency benchmarks for VHS graduates, encompassing attitudes, knowledge, and skills [37, 38, 39]. The main criterion for the implementation of VHS is the formation of competencies with standardisation in accordance with the needs of the world of work. A pedagogical methodology garnering increasing attention in vocational education is Self-Design Project Learning (SDPL) [40]. SDPL stands out as a pedagogical model deemed suitable for adoption within vocational education settings. The fundamental aim of the SDPL framework is to align the caliber of vocational graduates with industry exigencies [41, 42]. SDPL is characterised by students acquiring proficiency in attitude, knowledge, and work skills through their engagement with products or projects. The SDPL framework comprises seven distinct stages, namely: (a) Product/Project Planning; (b) Implementation; (c) Inquiry and Development; (d) Collaboration; (e) Evaluation; (f) Presentation; and (g) Reflection [43, 44, 45, 46].

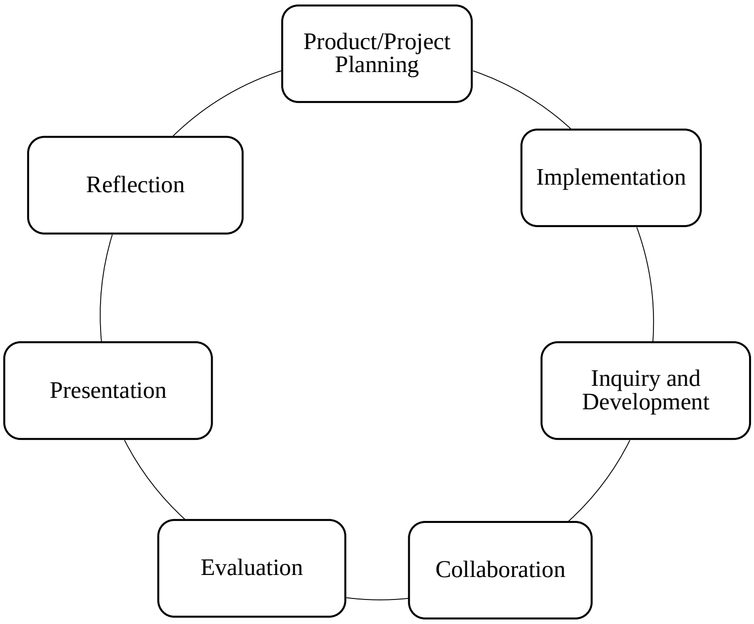

Fig. 1. Stages of the Self Design Project Learning (SDPL) Model

The i-SDPL (Integrated Project-Based Learning) model represents a refinement of traditional Project-Based Learning (PjBL), aimed at addressing the inherent limitations observed in the standard SDPL approach. Recent scholarly investigations, as documented by Hariyanto et al. (2023), Nilsook et al. (2021), and R. Zhang et al. (2023), have underscored deficiencies primarily pertaining to collaborative dynamics and the degree of industrial engagement within the educational milieu. These shortcomings have prompted a concerted effort to reconceptualise the SDPL framework, thereby fostering a more symbiotic relationship between academia and industry [47, 48, 49].

The integration of i-SDPL with industrial imperatives is multifaceted, encompassing several key facets. Firstly, it necessitates the alignment of educational objectives with the dynamic demands of contemporary industries. This alignment ensures that curricular content is not only relevant but also responsive to the evolving needs of the professional landscape. Secondly, the collaborative partnership between educators and industry stakeholders assumes paramount significance. By fostering close ties between these two spheres, i-SDPL endeavors to bridge the gap between theoretical knowledge and practical application, thereby imbuing students with a holistic understanding of their chosen vocation. Finally, the utilisation of industrial infrastructure serves to immerse students in an authentic work environment, thereby providing firsthand exposure to the challenges and nuances of their respective industries.

Ultimately, the overarching goal of integrating the i-SDPL model with industry is to enhance the vocational preparedness of students enrolled in Vocational High Schools (VHS) while simultaneously mitigating the incidence of post-graduation unemployment. Through a synergistic blend of academic rigor and real-world applicability, i-SDPL seeks to empower students with the requisite skills and competencies to thrive in an increasingly competitive job

Methodology, Materials and Methods

This study employed Richey and Klein's research and development design, comprising three distinct stages of inquiry [54]. The stages of the research and development of the Integrated industry Self-Design Project Learning model are divided into 3 stages. These stages are needs analysis, internal validation and external validation. The needs analysis stage aims to explore information about the condition of learning in VHS, what aspects of competence are needed by the industry and VHS and what materials are currently needed by the industry and can be integrated with a product / project-based learning model. This stage involves 10 teachers and 12 industry practitioners to ensure that learning needs are accurately identified and aligned with industry requirements.

The Internal Validation stage aims to obtain feedback from experts to ensure that the learning model and Practical Performance Test instruments are suitable for application in the External Validation stage. This stage involves 2 vocational education experts and 2 industry practitioners who assess the feasibility of the developed models and instruments. Their input is used to refine and adjust the models before wider testing. The External Validation stage focuses on evaluating the effectiveness of the learning model in enhancing students' work readiness. This process involves a series of tests and trials, beginning with a pretest involving 32 students, followed by a limited test with 20 students, and culminating in a broader trial with 136 students. This phased approach allows for a thorough evaluation of the learning model, from small

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educational setting. The sequential progression of these research stages is illustrated in Figure 2.

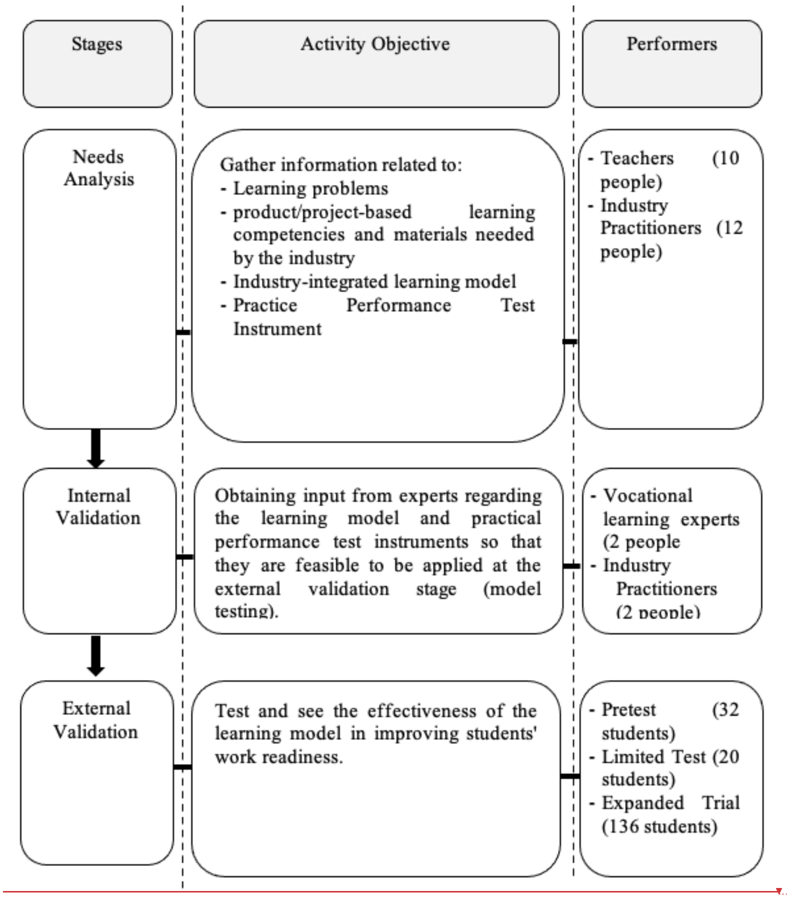

Fig. 2. Research and development procedures

The data collection methodologies employed in this study encompassed both test-based and non-test-based approaches. Non-test methodologies comprised interviews and questionnaires. The test-based methodology entailed a practical performance examination. Interviews were conducted through focused group discussions to glean insights into learning impediments,

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Table 1

The internal validation instrument grids

No	Criteria	Assessment indicators
1	Relevance	The learning model is relevant to the learning objectives to be achieved
2	Necessity	The learning model is appropriate to the needs and characteristics of students.
3	Clarity	The instructions and steps in the learning model are clearly presented and easy to understand.
4	Readability	The language used in the learning model is easy to understand by students, teachers and industry practitioners.
5	Applicability	The learning model can be applied in the context of classroom learning
6	Effectiveness	The learning model is effective in improving aspects of student competence
7	Suitability to the curriculum	The learning model is in accordance with the applicable curriculum and is able to support the achievement of basic competencies that have been determined
8	Industry participation	The learning model encourages industry participation

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To see the feasibility of the learning model and practical performance assessment instruments, validation and input from experts consisting of vocational education/learning experts and industry practitioners are required. Furthermore, the learning model and practical performance assessment instruments resulting from internal validation are applied to the external validation stage to determine the effectiveness of the learning model in improving students' work readiness. The internal validation instrument grids for experts and learning evaluation instruments can be seen in Table 1 and Table 2, respectively.

Table 2

Learning evaluation instruments

Competencies	Competency aspect
Attitude	Thoroughness
	Teamwork
	Hard work and discipline
	Creativity and innovation
Knowledge	Technical knowledge
	Material knowledge
Skills	Mechanical skills
	Information technology skills

The validity and reliability of the interview, questionnaire, and performance test instruments were assessed through rigorous content validity tests conducted by experts drawn from the realms of vocational learning and industry. Specifically, these experts held positions as car service advisors, ensuring a specialised understanding of the subject matter. Reliability testing, on the other hand, was executed utilising the Cronbach's alpha (α) test, a renowned measure known for its ability to ascertain internal consistency reliably. The outcomes consistently affirmed the instruments' reliability. The assessment instrument for the student practical performance test underwent meticulous development, spearheaded by VHS Automotive Engineering educators, automotive industry practitioners, and vocational learning authorities. Drawing upon the seminal research titled "Development of an Industry-Oriented Experiential Learning (EL+i) Model to Enhance Vocational High School Students' Job Readiness", as delineated in Table 3, the instrument was tailored to suit the exigencies of the study [55].

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Table 3

Categorisation of questionnaires and practical performance tests

Score	**Category**
3.01 - 4.00	Very Effective
2.51 - 3.00	Effective
2.01 - 2.50	Less effective

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Quantitative data analysis served as the cornerstone for evaluating both the model's feasibility questionnaire instrument and the practical performance assessment instrument, alongside the subsequent analysis of the practical performance test results. This analytical approach facilitated comprehensive categorisation and interpretation of the amassed data.

Research Results

Needs Analysis

The needs analysis stage aims to investigate learning challenges, required competencies, and the product or project-based learning materials necessary for industry integration. Data analysis was conducted through focus group discussions involving participants from vocational high school automotive engineering teachers and automotive industry practitioners. The findings from the needs analysis stage are presented in Table 4, Table 5, and Figure 3. The results indicate that the current industry demands product and project-based learning materials, specifically in the areas of electric vehicle modification, gas and electric welding, and oven painting.

Table 4

Learning problems

No	Indicators	Vocational School Teachers	Industry Practitioners
1.	Learning Planning	Teachers plan lessons in accordance with the instructions of related agencies; there is no role for industry.	VHSs do not collaborate with industry in lesson planning.
2.	Learning Implementation	During this time, the implementation of learning is done by teachers themselves; the role of industry is absent.	VHSs passively collaborate and cooperate with industry in the implementation of learning.
3.	Evaluation of Learning	VHS-based evaluation; no industry role.	VHS collaboration with industry is limited to graduation competency tests. Not implemented on every competency indicator required by

			VHS.
4.	Graduate Quality	The quality of graduates is not certified by the industry.	The quality of graduates depends on the results of the VHS process, while industry contributes minimally.

The analysis reveals significant deficiencies in the collaboration between vocational high schools and industry in planning, implementation, evaluation, and graduate quality. The curriculum is developed and implemented unilaterally by vocational high schools without industry participation. Thus, industry involvement is lacking. Evaluation is primarily managed by vocational high schools, with industry participation limited to graduation competency tests, resulting in graduates lacking industry certification. To address these issues, it is recommended to establish partnerships between vocational high schools and industry to co-develop curricula that integrate current industry standards and practices.

Industry professionals should actively participate in teaching and provide practical training, while continuous evaluation involving industry practitioners should be implemented to ensure students meet the required competencies. In addition, certification processes developed in collaboration with industry should validate graduates' skills and knowledge, thereby improving their employability and ensuring vocational education is aligned with current industry standards.

Industry practitioners work together with vocational high schools to play an active role in the planning, implementation, evaluation, certification and sustainability of vocational high school graduates to form competency completeness that meets industry criteria.

Table 5

Competencies required by industry

Competencies	Competency Aspect	Description
Attitude	Thoroughness	Ability to perform work with detail and accuracy.
	Teamwork	Ability to work with others in a team, collaborate and support each other to achieve common goals.

	Hard Work and Discipline	Ability to complete tasks in a timely manner and to a high standard of quality.
	Creativity and Innovation	Ability to think beyond predictions, seek new solutions, or improve existing processes.
Knowledge	Technical Knowledge	Ability about the principles, concepts, and specific details of a field of technology or science.
	Material Knowledge	Understanding of the types of materials, their properties, processing methods and applications in technology, their properties, optimal use, and ways of processing and application in various contexts.
Skills	Mechanical Skills	Skills in maintenance and repair of work equipment and field of work.
	Information Technology Skills	Skills in using software and related technology that supports work processes in industry.

The listed competencies are comprehensive and encompass essential areas for vocational students, particularly those specialising in electric vehicles. Attitude-related competencies prepare students to work effectively and innovate within teams. Knowledge-based competencies provide the theoretical foundation necessary for understanding and applying technical concepts. Skill-related competencies ensure students can perform practical tasks and utilise modern technologies proficiently. Integrating these competencies into vocational education can significantly enhance students' readiness for the workforce, especially in technical and rapidly advancing fields such as electric vehicle technology.

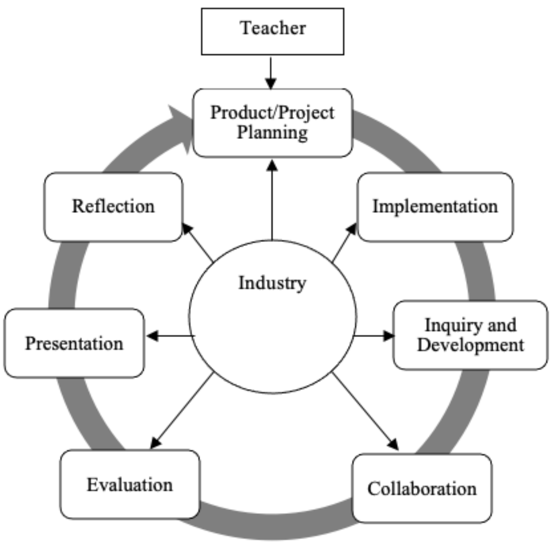

Fig. 3. i-SDPL Learning Model from Needs Analysis (Conceptual)

Internal Validation

The internal validation stage aims to determine feasibility and seek input and suggestions from experts regarding the feasibility of practical performance assessment models and instruments, which will be applied at the external validation (trial) stage. Experts involved in the internal validation stage include: (a) vocational learning lecturers with over 15 years of academic experience, automotive competency certificates, and relevant work in automotive engineering, and (b) industry practitioners with over 10 years of experience as service advisors or workshop heads. The results of the internal validation indicate that the practical performance assessment instrument aligns with the measured competencies, rubric criteria, and scoring.

Regarding the industry-integrated i-SDPL learning model, the following are key points generated from the internal validation stage: (a) i-SDPL

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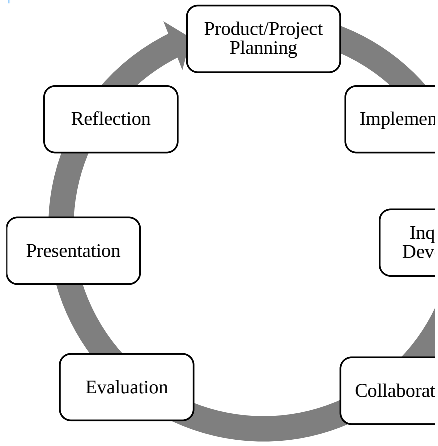

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emphasises collaboration between industry and educators at every stage of the model. (b) Implementation of the model is feasible in both vocational schools and industry, taking into account the availability of learning facilities and infrastructure. (c) Evaluation occurs in the industry with graduation standards aligned with industry needs. The revised i-SDPL learning model, incorporating feedback from the internal validation stage, is illustrated in Figure 4.

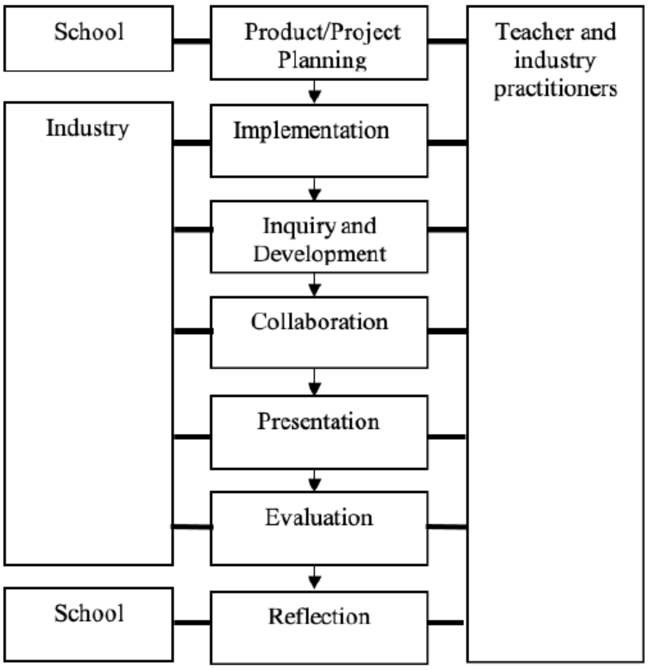

Fig. 4. Used Industry Integrated Self Design Project Learning Model (i-SDPL)

The i-SDPL model contains stages that aim to shape the work readiness of the rest of the vocational school. (a) Product/project planning contains activities aimed at establishing clear learning objectives, selecting appropriate projects/products, and scheduling their implementation. (b) The implementation stage contains student activities in implementing learning in accordance with the learning plan. Teachers and industry practitioners ensure learning outcomes

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comply with industry standards. This phase is important for grounding theoretical knowledge in practical application.

(c) The investigation and development stage encourages students to complete learning tasks according to the knowledge and skills they have acquired. (d) The collaboration stage is the stage where students interact directly with industry practitioners to gain experience, knowledge and skills according to the needs of the industrial world. (e) The presentation stage contains activities to demonstrate the results of the problem solving process/tasks that have been studied. Here communication will be formed and produce input from other students, teachers and industry practitioners. (f) The evaluation stage contains competency tests and feedback that are in line with industry standards. (g) The final stage, reflection, allows teachers and industry practitioners to assess learning outcomes and develop further strategies for developing student competencies.

Table 4

Stages of Industry Integrated Self Design Project Learning Model (i-SDPL)

Model Stages	Activities	Time
Product/Project Planning	Industry Practitioner and Teacher together: Determine learning objectives Determine the project or product that will be used for learning Inform students about the work plan and schedule for learning implementation Divide the group	Before learning
Implementation	Students start practicing and working according to the projects planned by teachers and industry practitioners Industry Practitioners and Teachers together provide guidance to students when needed	According to industry standards
Inquiry and Development	Students complete a project/product Apply the attitudes, knowledge and skills gained from learning Industry Practitioners and Teachers together provide guidance to students when needed	
Collaboration	Students interact with industry practitioners who are experienced in completing projects / products	
Presentation	Students present the results of the project / product that is done	10 minutes/group
Evaluation	Teachers and industry practitioners evaluate student progress on a regular basis	As per industry standard

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	Teachers or industry practitioners conduct competency tests	
	Teachers and industry practitioners summarise and provide feedback to students	
Reflection	Teachers and industry practitioners reflect on learning outcomes and plan steps for student competency development.	At the end of the lesson

External Validation

The external validation stage is divided into two: limited trial and extended trial stages. The purpose of external validation is to determine the effectiveness of the i-SDPL model in improving the work readiness of vocational students. External validation activities began with a pretest involving 32 students of VHS Muhammadiyah 2 Tempel. The subject matter tested was welding with a motorcycle chain cover project. The limited trial was conducted at VHS Muhammadiyah 1 Salam Magelang involving 20 students who studied welding with a toolbox project. Meanwhile, the extended trial was conducted at SMK Muhammadiyah 1 Salam and SMK Muhammadiyah Pakem, involving 136 students from the Automotive Engineering Department.

The analysis of the table indicates significant improvements across various categories attitude, knowledge, and skills from pretest to posttest. In the attitude category, there was a notable increase in creativity and innovation, with scores rising from 1.4 in the pretest to 3.6 in the posttest. Although some categories, such as conscientiousness and hard work and discipline, experienced a decline during the trials stage, both showed significant improvement in the posttest. The knowledge category also demonstrated a positive upward trend, with material knowledge increasing from 1.6 in the pretest to 3.6 in the posttest. Similarly, the skills category exhibited growth, with information technology skills improving from 1.4 in the pretest to 3.4 in the posttest.

Overall, these results suggest that the implemented programme or intervention was successful in enhancing participants' attitudes, knowledge, and skills, despite some fluctuations during the trials stage. This indicates that, despite initial challenges, participants were able to overcome and significantly

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improve their abilities through the learning process or intervention conducted. The results of the external validation stage can be seen in Figure 5.

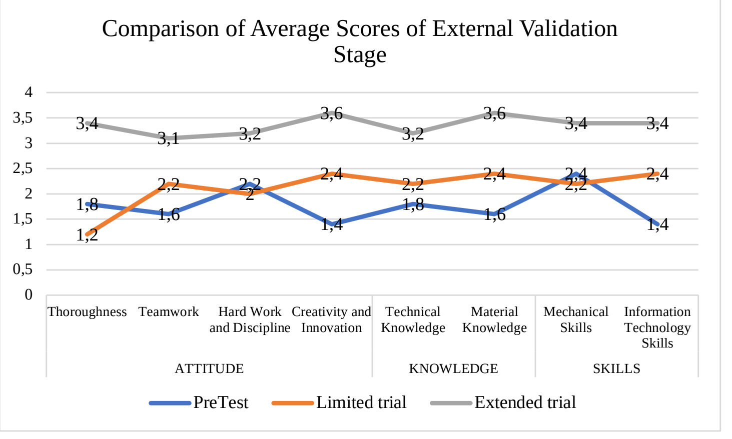

Fig. 5. Comparison of average scores of external validation stage

Results and Discussion

The Industry Integrated Self Design Project Learning (i-SDPL) Model, derived from the Project-Based Learning (PjBL) framework, emphasises the development of student competencies through direct engagement with industry-related projects and products [45, 56, 57]. This model integrates theoretical and practical learning, fostering a holistic development of attitudes, knowledge, and skills. Key characteristics of the i-SDPL model include its collaborative approach, where educators and industry practitioners work together to guide students. The curriculum is aligned with industry standards, ensuring that the competencies students acquire are relevant and up-to-date with current industrial demands. Furthermore, the model includes rigorous stages of implementation and evaluation, conducted within industrial settings, which immerse students in real-world work environments. This not only bridges the

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gap between classroom learning and industry practice but also facilitates a smoother transition for students into the workforce.

In the i-SDPL learning model, the integration of project- and product-based learning with industry standards is pivotal in shaping student competencies to meet industry needs. By working on real-life industry projects, students gain practical experience and develop skills that are directly applicable in their future careers. This experiential learning approach not only enhances technical proficiency but also fosters critical thinking, problem-solving, and collaboration skills. Exposure to the industrial climate plays a crucial role in preparing students for professional environments by enhancing their understanding of industrial processes and work culture. This comprehensive exposure helps in developing the character and work readiness of vocational high school (VHS) students, making them more adaptable and capable of meeting the challenges of the modern industrial landscape [58, 59, 60]. The i-SDPL model, therefore, represents a significant advancement in vocational education by ensuring that students are not only academically proficient but also industry-ready.

The i-SDPL learning model has been demonstrated to be highly effective in enhancing work readiness across various dimensions, including attitudes, knowledge, and skills. This model significantly improves competence in the attitude of accuracy. Project-based learning, a core component of the i-SDPL model, emphasises the final product's quality. To achieve a high-quality product, students must meticulously attend to every detail and ensure that each step is executed carefully, thereby consistently developing a thoroughness attitude [61, 62]. Additionally, the i-SDPL learning model is an effective method for fostering competence in teamwork attitudes. Student collaboration/cooperation in producing products/projects forms students' competence in discussing and providing different knowledge [63, 64].

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The competency of hard work and discipline refers to a person's ability to complete tasks on time with high quality standards. Through the application of the i-SDPL learning model by producing projects or products, students can create work that meets industry standards, which emphasise completeness, efficiency and perfection. With the consistent application of i-SDPL, an optimal attitude of hard work and discipline will be formed [65, 66, 67]. The next attitude competency is creativity and innovation. The application of i-SDPL will strengthen students' creativity and innovation attitude. In the process of making products, students repeatedly receive feedback/direction from industry practitioners and teachers. The process encourages students to always innovate, looking for new ways to improve the quality of the products they produce, so that their competencies in creativity and innovation develop progressively [68, 69, 70].

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Motivational factors for all participants in the i-SDPL model include aspects from students, teachers, and industries involved in the learning process. The i-SDPL learning model stimulates students to understand and apply concepts and theories in product manufacturing. Through the i-SDPL learning model, students more easily understand the relevance and importance of technical knowledge in practical applications. Not only that, but this model also facilitates students to directly experience the process and challenges of completing a project or product. These activities encourage students to develop technical skills from planning, implementation, to evaluation [71, 72]. Furthermore, the i-SDPL learning model enhances students' material knowledge competency. The industry-integrated approach of i+SDPL emphasises that application in completing projects or products will shape students' attitudes, knowledge and work skills. Students can observe how material theories and concepts are applied in real situations of making projects or products. The industry-based product-based learning model provides a deep understanding of the use and processing of materials in a practical context [73, 74, 75].

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For teachers, motivation comes from their role as facilitators who not only teach theory but also guide students in industry-based projects. This model allows teachers to update their insights through co-operation with industry as well as develop more innovative and effective learning methods. In addition, students' success in producing quality projects is a source of satisfaction for educators.

For the industry, involvement in SDPL is an opportunity to get a more prepared and skilled workforce candidate according to the company's needs. By participating in the design and evaluation of projects, industries can ensure that graduates have competencies that meet their standards. In addition, this model also helps the industry to build close relationships with educational institutions, which can lead to wider cooperation in the future.

Mechanical skills competency refers to a person's practical ability to understand, maintain, repair and operate equipment and machine components. The i-SDPL learning model is developed in accordance with industry needs and standardisation. Through the application of the model, students get the opportunity to apply mechanical theories and concepts in making projects or products. Working according to industry standards, students are able to understand how mechanical principles apply in a real industrial context [76, 77, 78, 79]. The project-based learning model integrated with industry can improve the competence of information technology skills. Through the completion of industry-standard projects or products, students have the opportunity to interact with a variety of tools, platforms and information technologies commonly used in the industrial world [79, 80, 81, 82]. These learning activities equip students with practical and technical skills in operating, maintaining and utilising various solutions using information technology [83, 84].

The i-SDPL model has several limitations that can affect its effectiveness. One of the main challenges is the limited collaboration with industry, especially

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for schools that do not have easy access to relevant companies. This can be overcome by building a wider network of partnerships through internship programmes, curriculum cooperation and industry visits. In addition, limited resources and infrastructure in some schools are also an obstacle in implementing this model. Solutions that can be applied are the utilisation of simulation technology, cooperation with companies for access to industrial facilities, and procurement of equipment through educational grants.

On the other hand, students' level of independence in learning varies, which can affect the smooth running of their projects. To overcome this, initial training on project management, more intensive guidance from teachers and industry mentors, and periodic evaluations are needed to ensure students' progress. In addition, the evaluation of competency standards is also a challenge due to differences in industry standards that may affect the objectivity of the assessment. Therefore, the development of a standardised assessment rubric with the industry is a solution to ensure a more accurate evaluation and in accordance with the needs of the world of work. An explanation of these limitations and their solutions can be included in the Discussion section to provide insight into the challenges of i-SDPL implementation and strategies to improve its effectiveness.

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Conclusion

The i-SDPL learning model is an innovative approach derived from the Project-Based Learning (PjBL) framework. This model's development stems from a comprehensive needs analysis and feedback from industry experts and practitioners. The distinguishing feature of the i-SDPL model is the integration of industry involvement at every stage of the learning process, including preparation, implementation, and evaluation. Moreover, the i-SDPL model is executed in a blended format, combining learning experiences in vocational

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high schools (VHS) and industry settings. The industry component is designed to acquaint students with the professional work environment at an early stage.

The i-SDPL learning model has demonstrated its efficacy in enhancing competencies in attitude, knowledge, and work skills through two trial implementations. The implementation of the model is intended to benefit not only students but also teachers. For educators, the i-SDPL model serves as a mechanism to update and expand their knowledge in line with current industry advancements.

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E. ROUND 3 (REVIEW 3)

HASIL CATATAN DAN PERBAIKAN

Round 3 (6 Maret 2025)			
No	Catatan	Perbaikan	Halaman
1	I have displayed items in a bulleted list	has been corrected	19
2	Industry-integrated ? Is Industry-Integrated Self-Design Project Learning a full name of the model? What is the right abbreviation for Industry-Integrated Self-Design Project Learning? i-SDPL ?	has been corrected Industry-Integrated Self-Design Project Learning (i-SDPL) model: an impactful approach to enhancing job readiness for vocational students	1
3	Table 4 Stages of industry integrated Self-Design Project Learning model (i-SDPL)	has been corrected	20

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Bambang Sudarsono 6 Mar 2025, 13.29
Thank you very much Prof. Anna, I look forward to hearing the good news

Анна Соловьева <anna_soloveva87@mail.ru> 6 Mar 2025, 16.13
kepada saya

Terjemahkan ke Indonesia

Dear Bambang Sudarsono,

Your paper is attached. Please, add authors' surnames and initials into the Discussion section as I have done in the section Literature Review (marked with yellow).

Please, mark all your modifications with the green colour.

Thank you.

Best wishes,
Anna

> Четверг, 6 марта 2025, 11:29 +05:00 от Bambang Sudarsono <bambang.sudarsono@pvto.uad.ac.id>:
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kepada Анна

Best wishes from Indonesia Prof Anna

I have improved the article as directed by Prof Anna. If there is anything that needs to be corrected again, I am ready to revise it.

Thank you very much

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Анна Соловьева — 10 Mar 2025, 13.57

Dear Bambang Sudarsono, I will write to you a bit later. I have got some questions. Best wishes, Anna Понедельник, 10 марта 2025, 11:40 +05:00 ...

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HASIL ARTIKEL YANG DIPERBAIKI
ROUND 3

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Integrated industry Self-Design Project Learning model: an impactful approach to enhancing job readiness for vocational students

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Abstract. Introduction. In 2023, graduates of Vocational High Schools (VHS) in Indonesia are still one of the highest contributors to the unemployment rate. This continuing problem is caused by the inadequate work readiness of VHS students. The main problem lies in the current educational approach which is still limited to vocational schools and less integrated with industry needs. *Aim*. The purpose of this study is to develop a product-based learning model that is aligned with industry needs and evaluate its effectiveness in improving the work readiness of vocational students. *Methodology and research methods.* This research was carried out in the stages of needs analysis, internal validation, and external validation. Data collection techniques consisted of test and non-test methods, using instruments such as interviews, questionnaires, and practical performance tests. *Results and scientific novelty*. The collected data were analysed descriptively and the results were interpreted using categorisation criteria. The findings show that the industry-integrated Self-Design Project Learning (i-SDPL) learning model and performance test measurement tools are very effective in the context of vocational education. Specifically, the i-SDPL learning model significantly enhanced students' work readiness, with average scores of 3.3 for attitude competency and 3.4 for both knowledge and skill competencies. The scientific novelty of the Self-Design Project Learning (SDPL) learning model lies in the integration of industry needs that enable students to develop competencies. Students are designed to carry out projects independently, thus fostering a deeper understanding of industry-relevant skills and knowledge. *Practical significance*. The implementation of the i-SDPL model is expected to encourage greater industry recognition of the competencies developed by VHS graduates and further strengthen the partnership pattern between VHS and industry.

Keywords**:** integrated industry, self-design project learning (i-SDPL), vocational students, job readiness

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Интегрированная отраслевая модель обучения самостоятельному проектированию проектов: эффективный подход к повышению профессиональной готовности учащихся

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Аннотация. *Введение.* В 2023 году выпускники профессионально-технических училищ (VHS) в Индонезии по-прежнему являются одним из самых высоких источников безработицы. Эта сохраняющаяся проблема вызвана недостаточной готовностью студентов VHS к работе. Основная проблема заключается в нынешнем образовательном подходе, который по-прежнему ограничен профессиональными учебными заведениями и в меньшей степени интегрирован с потребностями промышленности. *Цель.* Целью данного исследования является разработка модели обучения, основанной на продукте, которая соответствует потребностям отрасли, и оценка ее эффективности в повышении готовности к работе студентов профессиональных учебных заведений. *Методология и методы исследования.* Данное исследование проводилось на этапах анализа потребностей, внутренней и внешней валидации. Методы сбора данных включали в себя тестовые и непроверенные методы с использованием таких инструментов, как интервью, анкетирование и практические тесты эффективности. *Результаты и научная новизна.* Собранные данные были проанализированы описательно, а результаты интерпретированы с использованием критериев категоризации. Полученные результаты показывают, что модель обучения i-SDPL и инструменты измерения результатов тестов очень эффективны в контексте профессионального образования. В частности, модель обучения i-SDPL значительно повысила готовность студентов к работе: средний балл за отношение к работе составил 3,3 балла, а за знания и навыки - 3,4 балла. *Научная новизна* модели обучения самостоятельному проектированию (SDPL) заключается в интеграции отраслевых потребностей, которые позволяют студентам развивать компетенции. Студенты разрабатываются для самостоятельного выполнения проектов, что способствует более глубокому пониманию навыков и знаний, имеющих отношение к отрасли. *Практическая значимость.* Ожидается, что внедрение модели i-SDPL будет способствовать более широкому признанию отраслью компетенций, приобретенных выпускниками VHS, и дальнейшему укреплению партнерских отношений между VHS и промышленностью.

Ключевые слова: интегрированная индустрия, самостоятельное проектное обучение (i-SDPL), студенты-профессионалы, готовность к работе

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Introduction

The Fourth Industrial Revolution, known as Industry 4.0, has brought about major changes in various sectors, including the world of work. In this era, the skills required are no longer limited to technical abilities, but also include soft skills such as critical thinking, creativity, and the ability to collaborate [1, 2]. Vocational high schools (VHSs) in Indonesia aim to produce a workforce that is competent and ready to face the world of work [3, 4, 5]. Therefore, adjustments are needed in the curriculum, learning methods, and competency standards to suit industry needs. However, there is still a gap between the world of education and the world of work, which causes VHS graduates to not be fully prepared to face challenges in the industry.

The industry-integrated Self-Design Project Learning (i-SDPL) model is emerging as a potential solution to address these challenges. The i-SDPL model is an extension of the existing SDPL model and emphasises the active involvement of students in designing and implementing relevant projects in learning. The main difference with the current SDPL model is that i-SDPL emphasises the active involvement of students in designing and implementing industry-relevant projects [6, 7]. In this model, students not only learn about theoretical concepts, but also apply their knowledge in real situations. Thus, students can develop technical skills and soft skills that are highly needed in the world of work [1, 8]. One of the advantages of i-SDPL is its ability to provide a more in-depth and contextualised learning experience for students. In their self-designed projects, students have to interact with various stakeholders, including teachers, industry professionals and peers [9, 10]. These interactions not only enrich their learning experience, but also help students build professional networks that can be useful in the future. In addition, students also learn to work in teams, resolve conflicts, and manage time effectively.

Integration with industry in SDPL provides opportunities for students to access the latest technology and practical knowledge that is not always available in an academic environment [11, 12]. Through collaboration with industry, students can keep up with the latest trends, understand market needs, and prepare themselves for upcoming challenges [13, 14]. This is especially important given the rapid changes in technology and the need for a flexible and adaptive workforce. Industry also benefits by being involved in the education process, such as identifying potential workforce candidates and contributing to the development of relevant curricula.

The perceptions of stakeholders, including students, teachers and industry, will be the main focus in assessing the success of this learning model. Students are expected to provide feedback on their learning experience, mastery of technical and soft skills, and the relevance of the project to industry needs. Teachers will provide perspectives on implementation challenges, benefits for improving the quality of learning, and the impact on teaching methods applied in the classroom. Meanwhile, the industry will assess students' work readiness, identify skills gaps, and provide recommendations to enhance the integration of SDPL with evolving industry demands.

In addition, this research will also assess how SDPL can be adapted and implemented in different contexts. Given the diversity of VHSs in Indonesia, it is important to understand the factors that may influence the successful implementation of this model, such as support from school management, availability of resources, and linkages with industry. This study will explore various strategies that can be used to overcome these challenges, as well as evaluate how this model can be integrated with existing educational programmes.

With the growing need for a ready and competent workforce, it is important to evaluate and update existing learning approaches. Industry-integrated SDPL (i-SDPL) offers an attractive model to improve the work readiness of vocational students [15]. The i-SDPL model emphasises student independence in designing and implementing industry-based projects, with direct integration in every stage of learning to improve work readiness. Its advantages lie in active industry involvement, real product-based learning, and holistic strengthening of technical competence and soft skills compared to conventional methods.

The performance of the i-SDPL model is evaluated based on three primary competency aspects, each with clear indicators and criteria: (a) Attitude. This is assessed through rigour, teamwork, diligence, discipline, as well as creativity and innovation, which reflect students' preparedness for a real work environment. (b) Knowledge. This is measured by the technical understanding and material knowledge required by the industry, ensuring that students master both the theory and its practical applications. (c) Skills. This encompasses mechanical and information technology skills, which are fundamental to industrial practice and the utilisation of modern technology [16, 17].

Overall, this research aims to provide a comprehensive insight into the development of an industry-integrated Self-Design Project Learning Model in VHS. By examining various aspects of this model, it is hoped that ways can be found to improve its effectiveness and provide maximum benefits for students. The results of this research are not only relevant for VHSs in Indonesia, but can also serve as a reference for vocational education institutions in other countries facing similar challenges.

Literature Review

Vocational High Schools (VHS) serve as educational institutions designed to prepare graduates for immediate entry into the workforce in their respective fields of expertise [18, 19]. VHS play a crucial role in meeting the labor demands of various industrial sectors. Consequently, the quality of VHS graduates directly impacts industrial productivity. According to S. Sukardi, W. Wildan, A. Subhani [15] and V. R. Palilingan, R. R. Oroh, M. S. S. Tumanduk et al. [20], well-prepared VHS graduates can seamlessly transition into the workforce, contributing effectively to their respective industries and enhancing overall productivity.

However, data from the Central Bureau of Statistics indicate that VHS graduates constitute the highest proportion of unemployed individuals, accounting for 9.6% of the total unemployment rate [21]. This high unemployment rate among VHS graduates can be attributed to several factors, with the primary issue being their level of job readiness [22]. Many graduates lack the necessary skills and practical experience demanded by employers, leading to a significant gap between education and employment. S. A. Rodzalan, N. N. Mohd Noor, N. H. Abdullah et al. and W. Schulz, H. Solga, R. Pollak stated that addressing this issue requires a comprehensive approach to improve the vocational training curriculum, incorporate industry-specific skills, and provide real-world experience to enhance the employability of VHS graduates [23, 24].

In the study conducted by A. Prianto, W. Winardi, U. N. Qomariyah, it is established that the readiness to enter the workforce among graduates of VHS is formed through a comprehensive learning process that includes theoretical instruction, practical training, and industry exposure [25]. Vocational high

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schools have been progressively enhancing the quality of their education by integrating advanced educational methods and updating their curricula to meet the evolving demands of the job market [25, 26]. These efforts encompass a variety of initiatives, including the adoption of modern teaching techniques, the improvement of learning facilities, and the use of technology-enhanced learning tools. Despite these advancements, the issue of high unemployment rates among VHS graduates remains a significant challenge, requiring further strategic interventions.

A critical component of addressing this challenge is the establishment of robust partnerships between vocational high schools and industries [27]. D. W.Drewery, T. J. Pretti, D. Church noted that such collaborations are essential for aligning the educational outcomes of VHS students with the specific skills, knowledge, and attitudes required by employers [28]. By engaging directly with industries, vocational schools can ensure that their curricula are not only relevant but also forward-looking, preparing students for current and future job market demands [29, 30]. These partnerships facilitate the exchange of valuable insights and allow for the adaptation of teaching methodologies to better meet industry standards. As pointed out by D. Borah, K. Malik, S. Massini and L. Underdahl, P. Akojie, M. Agustin Magabo et al., industry involvement in the education process can provide students with practical experience and real-world exposure, further enhancing their readiness for employment [31, 32].

I. García-Martínez, M. Montenegro-Rueda, E. Molina-Fernández et al. and S. U. Nsanzumuhire, W. Groot reported that a systematic approach is required to effectively implement these industry-school collaborations [33, 34]. This includes conducting comprehensive needs analyses to identify the specific competencies demanded by various sectors, developing detailed task descriptions that outline the expected job roles, and establishing clear competency standards that serve as benchmarks for student performance.

Additionally, creating rigorous assessment procedures is crucial for evaluating whether students have acquired the necessary skills and knowledge. These assessments should be designed in consultation with industry experts to ensure their relevance and accuracy. Through these collaborative efforts, vocational high schools can produce graduates who are not only academically proficient but also possess the practical capabilities and professional attitudes required to thrive in the workforce [35, 36].

S. McGrath, S. Yamada [37], P. S. Rebia, Suharno, A. G. Tamrin et al. [38] and D. Rachmawati, S. Suharno, R. Roemintoyo [39] highlighted the pivotal factor contributing to the effective cultivation of work readiness among graduates of VHS, which resides in the proactive engagement of the industry in establishing competency benchmarks for VHS graduates, encompassing attitudes, knowledge, and skills. The main criterion for the implementation of VHS is the formation of competencies with standardisation in accordance with the needs of the world of work. L. Jie, T. Choicharoen, S. Juithong identified Self-Design Project Learning (SDPL) as a pedagogical methodology garnering increasing attention in vocational education [40]. SDPL stands out as a pedagogical model deemed suitable for adoption within vocational education settings. The fundamental aim of the SDPL framework is to align the caliber of vocational graduates with industry exigencies [41, 42]. SDPL is characterised by students acquiring proficiency in attitude, knowledge, and work skills through their engagement with products or projects. Much of the research conducted by F. N. Fauziah, K. Saddhono, E. Suryanto [43], N. B. Muliawan, I. A. Sulistijono [44], I. Tejawiani, I. Lastriyani, L. Lidiawati et al. [45] and M. A. Almulla [46] has focused on identifying the SDPL framework comprises seven distinct stages, namely: (a) Product/Project Planning; (b) Implementation; (c) Inquiry and Development; (d) Collaboration; (e) Evaluation; (f) Presentation; and (g) Reflection.

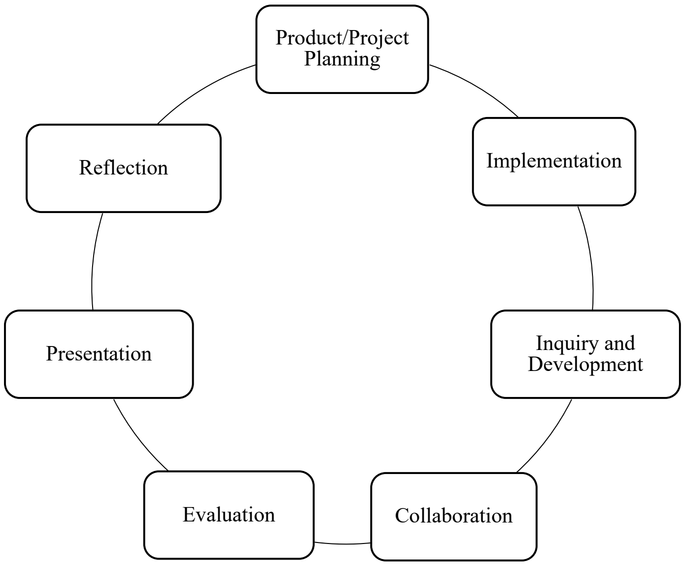

Fig. 1. Stages of the Self-Design Project Learning (SDPL) model

The i-SDPL (Integrated Project-Based Learning) model represents a refinement of traditional Project-Based Learning (PjBL), aimed at addressing the inherent limitations observed in the standard SDPL approach. Recent scholarly investigations, as documented by R. Zhang, J. Shi, J. Zhang [47], V. L. Hariyanto, R. Hidayah, G. N. I. Putra Pratama et al. [48], and P. Nilsook, P. Chatwattana, T. Seechaliao [49], have underscored deficiencies primarily pertaining to collaborative dynamics and the degree of industrial engagement within the educational milieu. These shortcomings have prompted a concerted effort to reconceptualise the SDPL framework, thereby fostering a more symbiotic relationship between academia and industry.

The integration of i-SDPL with industrial imperatives is multifaceted, encompassing several key facets. Firstly, it necessitates the alignment of educational objectives with the dynamic demands of contemporary industries. This alignment ensures that curricular content is not only relevant but also responsive to the evolving needs of the professional landscape. Secondly, the collaborative partnership between educators and industry stakeholders assumes paramount significance. By fostering close ties between these two spheres, i-SDPL endeavours to bridge the gap between theoretical knowledge and practical application, thereby imbuing students with a holistic understanding of their chosen vocation. Finally, the utilisation of industrial infrastructure serves to immerse students in an authentic work environment, thereby providing firsthand exposure to the challenges and nuances of their respective industries.

Ultimately, the overarching goal of integrating the i-SDPL model with industry is to enhance the vocational preparedness of students enrolled in Vocational High Schools (VHS) while simultaneously mitigating the incidence of post-graduation unemployment. Through a synergistic blend of academic rigor and real-world applicability, i-SDPL seeks to empower students with the requisite skills and competencies to thrive in an increasingly competitive job market. Moreover, by fostering a culture of collaboration and partnership between academia and industry, i-SDPL not only serves the immediate interests of students but also contributes to the broader socio-economic development of the communities it serves [50, 51, 52, 53].

Methodology, Materials and Methods

This study employed J. D. Richey's and R. C. Klein's research and development design, comprising three distinct stages of inquiry [54]. The stages of the research and development of the integrated industry Self-Design Project Learning model are divided into 3 stages. These stages are needs analysis, internal validation and external validation. The needs analysis stage aims to explore information about the condition of learning in VHS, what aspects of competence are needed by the industry and VHS and what materials are currently needed by the industry and can be integrated with a product / project-based learning model. This stage involves 10 teachers and 12 industry practitioners to ensure that learning needs are accurately identified and aligned with industry requirements.

The Internal Validation stage aims to obtain feedback from experts to ensure that the learning model and Practical Performance Test instruments are suitable for application in the External Validation stage. This stage involves 2 vocational education experts and 2 industry practitioners who assess the feasibility of the developed models and instruments. Their input is used to refine and adjust the models before wider testing. The External Validation stage focuses on evaluating the effectiveness of the learning model in enhancing students' work readiness. This process involves a series of tests and trials, beginning with a pretest involving 32 students, followed by a limited test with 20 students, and culminating in a broader trial with 136 students. This phased approach allows for a thorough evaluation of the learning model, from small groups to larger cohorts, ensuring its effectiveness and reliability in an educational setting. The sequential progression of these research stages is illustrated in Figure 2.

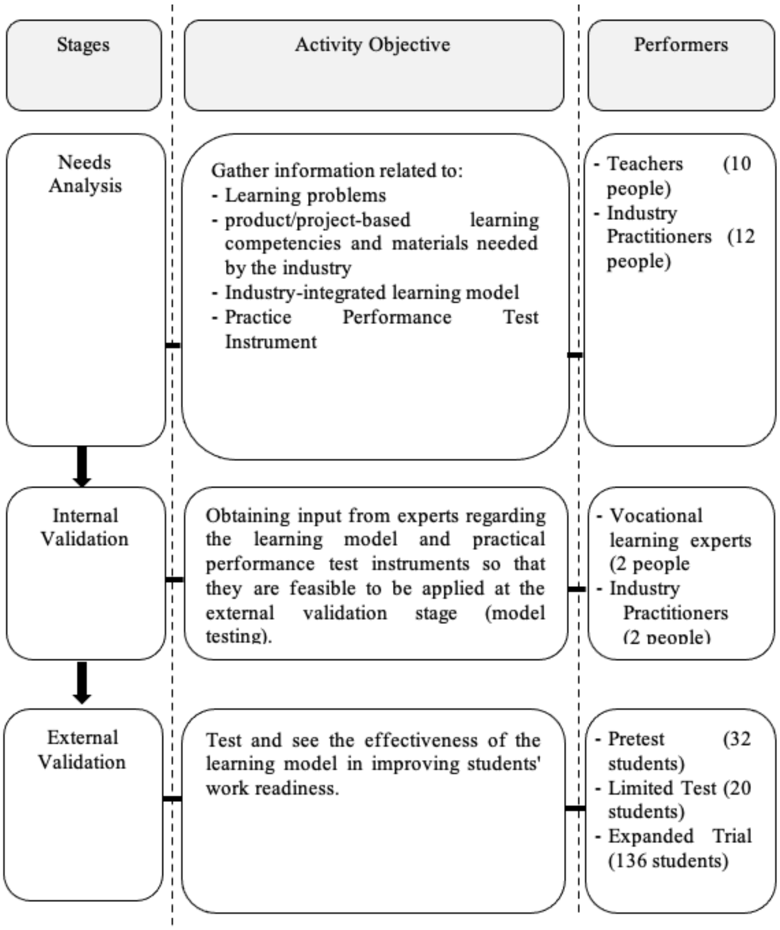

Fig. 2. Research and development procedures

The data collection methodologies employed in this study encompassed both test-based and non-test-based approaches. Non-test methodologies comprised interviews and questionnaires. The test-based methodology entailed a practical performance examination. Interviews were conducted through focused group discussions to glean insights into learning impediments, competencies, and the requisite product/project-oriented learning materials essential for industry integration.

Table 1

The internal validation instrument grids

No	Criteria	Assessment indicators
1	Relevance	The learning model is relevant to the learning objectives to be achieved
2	Necessity	The learning model is appropriate to the needs and characteristics of students.
3	Clarity	The instructions and steps in the learning model are clearly presented and easy to understand.
4	Readability	The language used in the learning model is easy to understand by students, teachers and industry practitioners.
5	Applicability	The learning model can be applied in the context of classroom learning
6	Effectiveness	The learning model is effective in improving aspects of student competence
7	Suitability to the curriculum	The learning model is in accordance with the applicable curriculum and is able to support the achievement of basic competencies that have been determined
8	Industry participation	The learning model encourages industry participation

To see the feasibility of the learning model and practical performance assessment instruments, validation and input from experts consisting of vocational education/learning experts and industry practitioners are required. Furthermore, the learning model and practical performance assessment instruments resulting from internal validation are applied to the external validation stage to determine the effectiveness of the learning model in improving students' work readiness. The internal validation instrument grids for experts and learning evaluation instruments can be seen in Table 1 and Table 2, respectively.

Table 2

Learning evaluation instruments

Competencies	Competency aspect
Attitude	Thoroughness
	Teamwork
	Hard work and discipline
	Creativity and innovation
Knowledge	Technical knowledge
	Material knowledge
Skills	Mechanical skills
	Information technology skills

The validity and reliability of the interview, questionnaire, and performance test instruments were assessed through rigorous content validity tests conducted by experts drawn from the realms of vocational learning and industry. Specifically, these experts held positions as car service advisors, ensuring a specialised understanding of the subject matter. Reliability testing, on the other hand, was executed utilising the Cronbach's alpha (α) test, a renowned measure known for its ability to ascertain internal consistency reliably. The outcomes consistently affirmed the instruments' reliability. The assessment instrument for the student practical performance test underwent meticulous development, spearheaded by VHS Automotive Engineering educators, automotive industry practitioners, and vocational learning authorities. Drawing upon the seminal research titled "Development of an Industry-Oriented Experiential Learning (EL+i) Model to Enhance Vocational High School Students' Job Readiness", as delineated in Table 3, the instrument was tailored to suit the exigencies of the study [55] .

Table 3

Categorisation of questionnaires and practical performance tests

Score	Category
3.01 – 4.00	Very Effective
2.51 – 3.00	Effective
2.01 – 2.50	Less effective
0 – 2.00	Ineffective

Quantitative data analysis served as the cornerstone for evaluating both the model's feasibility questionnaire instrument and the practical performance assessment instrument, alongside the subsequent analysis of the practical performance test results. This analytical approach facilitated comprehensive categorisation and interpretation of the amassed data.

Research Results

Needs Analysis

The needs analysis stage aims to investigate learning challenges, required competencies, and the product or project-based learning materials necessary for industry integration. Data analysis was conducted through focus group discussions involving participants from vocational high school automotive engineering teachers and automotive industry practitioners. The findings from the needs analysis stage are presented in Table 4, Table 5, and Figure 3. The results indicate that the current industry demands product and project-based learning materials, specifically in the areas of electric vehicle modification, gas and electric welding, and oven painting.

Table 4

Learning problems

No	Indicators	Vocational School Teachers	Industry Practitioners
1.	Learning Planning	Teachers plan lessons in accordance with the instructions of related agencies; there is no role for industry.	VHSs do not collaborate with industry in lesson planning.
2.	Learning Implementation	During this time, the implementation of learning is done by teachers themselves; the role of industry is absent.	VHSs passively collaborate and cooperate with industry in the implementation of learning.
3.	Evaluation of Learning	VHS-based evaluation; no industry role.	VHS collaboration with industry is limited to graduation competency tests. Not implemented on every competency indicator required by VHS.
4.	Graduate Quality	The quality of graduates is not certified by the industry.	The quality of graduates depends on the results of the VHS process, while industry contributes minimally.

The analysis reveals significant deficiencies in the collaboration between vocational high schools and industry in planning, implementation, evaluation, and graduate quality. The curriculum is developed and implemented unilaterally by vocational high schools without industry participation. Thus, industry involvement is lacking. Evaluation is primarily managed by vocational high schools, with industry participation limited to graduation competency tests, resulting in graduates lacking industry certification. To address these issues, it is recommended to establish partnerships between vocational high schools and industry to co-develop curricula that integrate current industry standards and practices.

Industry professionals should actively participate in teaching and provide practical training, while continuous evaluation involving industry practitioners should be implemented to ensure students meet the required competencies. In addition, certification processes developed in collaboration with industry should validate graduates' skills and knowledge, thereby improving their employability and ensuring vocational education is aligned with current industry standards.

Industry practitioners work together with vocational high schools to play an active role in the planning, implementation, evaluation, certification and sustainability of vocational high school graduates to form competency completeness that meets industry criteria.

Table 5

Competencies required by industry

Competencies	Competency aspect	Description
Attitude	Thoroughness	Ability to perform work with detail and accuracy.
	Teamwork	Ability to work with others in a team, collaborate and support each other to achieve common goals.
	Hard Work and Discipline	Ability to complete tasks in a timely manner and to a high standard of quality.
	Creativity and Innovation	Ability to think beyond predictions, seek new solutions, or improve existing processes.
Knowledge	Technical Knowledge	Ability about the principles, concepts, and specific details of a field of technology or science.
	Material Knowledge	Understanding of the types of materials, their properties, processing methods and applications in technology, their properties, optimal use, and ways of processing and application in various contexts.
Skills	Mechanical Skills	Skills in maintenance and repair of work equipment and field of work.
	Information Technology	Skills in using software and related technology that

Skills	supports work processes in industry.

The listed competencies are comprehensive and encompass essential areas for vocational students, particularly those specialising in electric vehicles. Attitude-related competencies prepare students to work effectively and innovate within teams. Knowledge-based competencies provide the theoretical foundation necessary for understanding and applying technical concepts. Skill-related competencies ensure students can perform practical tasks and utilise modern technologies proficiently. Integrating these competencies into vocational education can significantly enhance students' readiness for the workforce, especially in technical and rapidly advancing fields such as electric vehicle technology.

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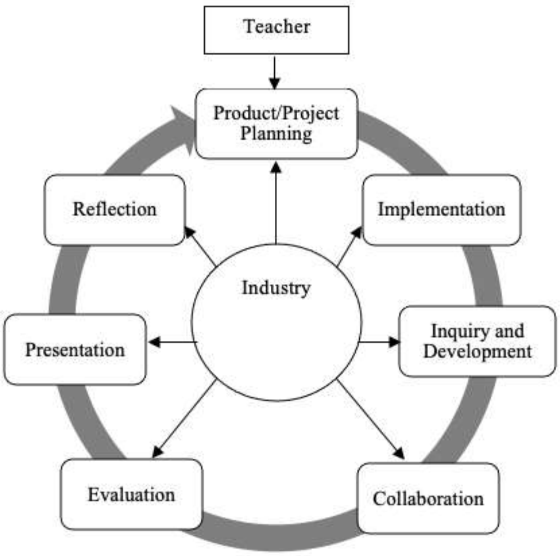

Fig. 3. i-SDPL Learning model from needs analysis (conceptual)

Internal Validation

The internal validation stage aims to determine feasibility and seek input and suggestions from experts regarding the feasibility of practical performance assessment models and instruments, which will be applied at the external validation (trial) stage. Experts involved in the internal validation stage include: (a) vocational learning lecturers with over 15 years of academic experience, automotive competency certificates, and relevant work in automotive engineering, and (b) industry practitioners with over 10 years of experience as service advisors or workshop heads. The results of the internal validation indicate that the practical performance assessment instrument aligns with the measured competencies, rubric criteria, and scoring.

Regarding the industry-integrated i-SDPL learning model, the following key points are generated from the internal validation stage: (a) i-SDPL emphasises collaboration between industry and educators at every stage of the model; (b) implementation of the model is feasible in both vocational schools and industry, taking into account the availability of learning facilities and infrastructure; (c) evaluation occurs in the industry with graduation standards aligned with industry needs. The revised i-SDPL learning model, incorporating feedback from the internal validation stage, is illustrated in Figure 4.

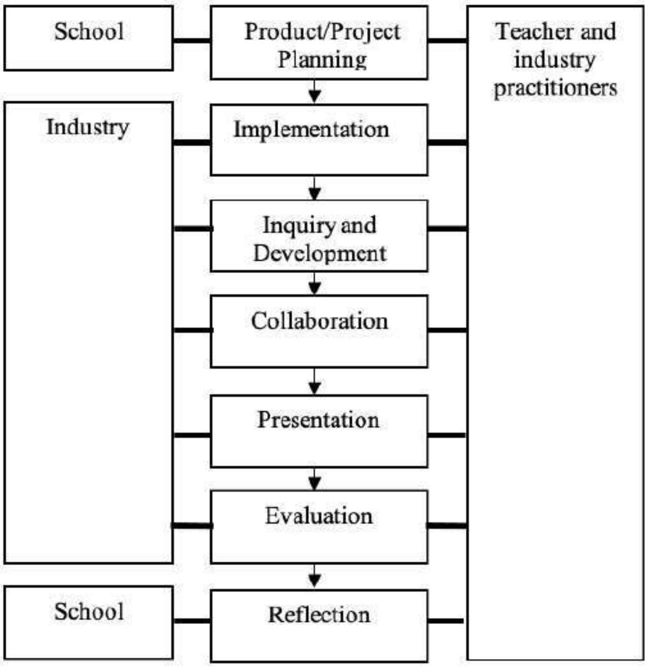

Fig. 4. Used Industry Integrated Self Design Project Learning Model (i-SDPL)

The i-SDPL model consists of stages that aim to shape the work readiness of the rest of the vocational school:

- The product/project planning contains activities aimed at establishing clear learning objectives, selecting appropriate projects/products, and scheduling their implementation.
- The implementation stage contains student activities in implementing learning in accordance with the learning plan. Teachers and industry practitioners ensure learning outcomes comply with industry standards. This phase is important for grounding theoretical knowledge in practical application.

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- The investigation and development stage encourages students to complete learning tasks according to the knowledge and skills they have acquired.
- The collaboration stage is the stage where students interact directly with industry practitioners to gain experience, knowledge and skills according to the needs of the industrial world.
- The presentation stage contains activities to demonstrate the results of the problem solving process/tasks that have been studied. Here communication will be formed and produce input from other students, teachers and industry practitioners.
- The evaluation stage contains competency tests and feedback that are in line with industry standards.
- The final stage, reflection, allows teachers and industry practitioners to assess learning outcomes and develop further strategies for developing student competencies.

Table 4

Stages of industry integrated Self-Design Project Learning model (i-SDPL)

Model stages	Activities	Time
Product/Project Planning	Industry Practitioner and Teacher together:	Before learning
	Determine learning objectives	
	Determine the project or product that will be used for learning	
	Inform students about the work plan and schedule for learning implementation	
	Divide the group	
Implementation	Students start practicing and working according to the projects planned by teachers and industry practitioners	According to industry standards
	Industry Practitioners and Teachers together provide guidance to students when needed	
Inquiry and Development	Students complete a project/product	
	Apply the attitudes, knowledge and skills gained from learning	
	Industry Practitioners and Teachers together provide guidance to students when needed	
Collaboration	Students interact with industry practitioners who are experienced in completing projects / products	

Presentation	Students present the results of the project / product that is done	10 minutes/group
Evaluation	Teachers and industry practitioners evaluate student progress on a regular basis	As per industry standard
	Teachers or industry practitioners conduct competency tests	
	Teachers and industry practitioners summarise and provide feedback to students	
Reflection	Teachers and industry practitioners reflect on learning outcomes and plan steps for student competency development.	At the end of the lesson

External Validation

The external validation stage is divided into two: limited trial and extended trial stages. The purpose of external validation is to determine the effectiveness of the i-SDPL model in improving the work readiness of vocational students. External validation activities began with a pretest involving 32 students of VHS Muhammadiyah 2 Tempel. The subject matter tested was welding with a motorcycle chain cover project. The limited trial was conducted at VHS Muhammadiyah 1 Salam Magelang involving 20 students who studied welding with a toolbox project. Meanwhile, the extended trial was conducted at SMK Muhammadiyah 1 Salam and SMK Muhammadiyah Pakem, involving 136 students from the Automotive Engineering Department.

The analysis of the table indicates significant improvements across various categories attitude, knowledge, and skills from pretest to posttest. In the attitude category, there was a notable increase in creativity and innovation, with scores rising from 1.4 in the pretest to 3.6 in the posttest. Although some categories, such as conscientiousness and hard work and discipline, experienced a decline during the trials stage, both showed significant improvement in the posttest. The knowledge category also demonstrated a positive upward trend, with material knowledge increasing from 1.6 in the pretest to 3.6 in the posttest. Similarly, the skills category exhibited growth, with information technology skills improving from 1.4 in the pretest to 3.4 in the posttest.

Overall, these results suggest that the implemented programme or intervention was successful in enhancing participants' attitudes, knowledge, and skills, despite some fluctuations during the trials stage. This indicates that, despite initial challenges, participants were able to overcome and significantly improve their abilities through the learning process or intervention conducted. The results of the external validation stage can be seen in Figure 5.

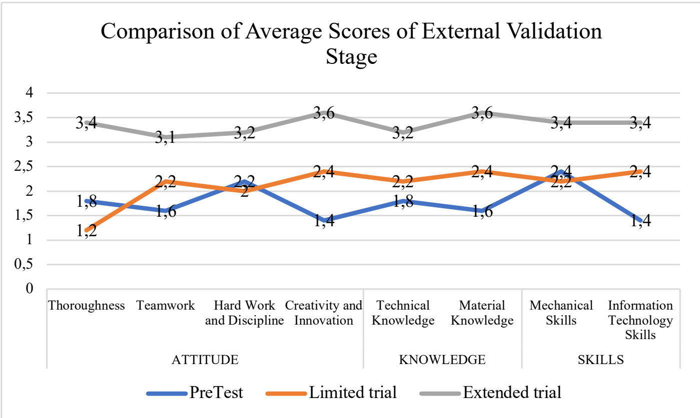

Fig. 5. Comparison of average scores of external validation stage

Results and Discussion

According to I. Tejawiani et. al. [45], D. Guile, C. Spinuzzi [56], and L. Youyou, A.C. Kit [57], the Industry Integrated Self-Design Project Learning (i-SDPL) model, derived from the Project Based Learning (PjBL) framework, emphasises the development of student competencies through direct engagement with industry-related projects and products. This model integrates theoretical and practical learning, fostering a holistic development of attitudes, knowledge, and skills. Key characteristics of the i-SDPL model include its collaborative approach, where educators and industry practitioners work together to guide students. The curriculum is aligned with industry standards, ensuring that the competencies students acquire are relevant and up-to-date with current industrial demands. Furthermore, the model includes rigorous stages of

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implementation and evaluation, conducted within industrial settings, which immerse students in real-world work environments. This not only bridges the gap between classroom learning and industry practice but also facilitates a smoother transition for students into the workforce.

According to C. Marnewick [58], H. Yudiono et.al. [59], and G. Pan et.al. [60], in the i-SDPL learning model, the integration of project- and product-based learning with industry standards is essential in shaping students' competencies to meet industry needs. By working on real industrial projects, students gain practical experience and develop skills that can be directly applied in their future careers. This experiential learning approach not only improves technical proficiency, but also encourages critical thinking, problem-solving and collaboration skills. Exposure to the industrial climate plays an important role in preparing students for the professional environment by enhancing their understanding of industrial processes and work culture. This comprehensive exposure helps develop the character and work readiness of vocational high school (VHS) students, making them more adaptable and able to face the challenges of the modern industrial landscape. The i-SDPL model, therefore, represents a significant advancement in vocational education by ensuring that students are not only academically proficient but also industry-ready.

According to A. Saepudin [61], the i-SDPL learning model has been shown to be highly effective in improving work readiness across multiple dimensions, including attitude, knowledge and skills. The model significantly improves competence in the attitude of rigour. H.B. Issa, A. Khataibeh [62], project-based learning, a core component of the i-SDPL model, emphasises the final quality of the product. To achieve a high-quality product, students must carefully pay attention to every detail and ensure that each step is performed carefully, thus consistently developing an attitude of rigour. In addition, G. Aydın, O. Mutlu [63] and U. Usmeldi [64], stated that the i-SDPL learning

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model is an effective method to foster competence in teamwork. Student collaboration/cooperation in producing products/projects forms student competence in discussion and provides different knowledge.

According to Z. Zen et. al. [65], L. Zhang, Y. Ma [66] and T.Q. Tran, T.N. Tran [67], work competence and discipline refer to a person's ability to complete tasks on time with high quality standards. Through the application of the i-SDPL learning model by producing projects or products, students can create work that meets industry standards, which emphasise completeness, efficiency and perfection. By applying i-SDPL consistently, an optimal attitude of hard work and discipline will be formed. The next attitude competency is creativity and innovation. According to S. Hanif et. al. [68], S.K. Ummah, et.al. [69] and A. Ahmad, B. Jabu [70], the application of i-SDPL will strengthen students' creativity and innovation attitudes. In the process of making products, students repeatedly receive input/direction from industry practitioners and teachers. The process encourages students to always innovate, looking for new ways to improve the quality of the products they produce, so that their creativity and innovation competencies are growing.

Motivational factors for all participants in the i-SDPL model include aspects from students, teachers, and industries involved in the learning process. The i-SDPL learning model stimulates students to understand and apply concepts and theories in product manufacturing. The question is supported by Syahril et. al. [71] and M.H. Shin [72], that through the i-SDPL learning model, students more easily understand the relevance and importance of technical knowledge in practical applications. Not only that, this model also facilitates students to experience firsthand the process and challenges of completing a project or product. This activity encourages students to develop technical skills from planning, implementation, to evaluation. In addition, the i-SDPL learning model improves students' material knowledge competence. This is supported by

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research results from N. Wijayati [73], E.C. Miller, J.S. Krajcik [74] and M. Nasir et.al. [75], that the i-SDPL approach integrated with industry emphasises that the application in completing projects or products will shape students' attitudes, knowledge, and work skills. Students can observe how the theory and concepts of the material are applied in the real situation of making projects or products. The industry-based product-based learning model provides a deep understanding of the use and processing of materials in a practical context.

For teachers, motivation comes from their role as facilitators who not only teach theory but also guide students in industry-based projects. This model allows teachers to update their insights through co-operation with industry as well as develop more innovative and effective learning methods. In addition, students' success in producing quality projects is a source of satisfaction for educators. For the industry, involvement in SDPL is an opportunity to get a more prepared and skilled workforce candidate according to the company's needs. By participating in the design and evaluation of projects, industries can ensure that graduates have competencies that meet their standards. In addition, this model also helps the industry to build close relationships with educational institutions, which can lead to wider cooperation in the future.

Mechanical skills competence refers to a person's practical ability to understand, maintain, repair and operate machine tools and components. The i-SDPL learning model is developed in accordance with industry needs and standardisation. Through the application of the model, students get the opportunity to apply the theory and concepts of machining in making projects or products. This question is in accordance with the results of research from W. Kurniawan, A. Budiono [76], H. Maksum, W. Purwanto [77], C.Y. Chao et.al. [78], and S. Syahril [79], who stated that by working according to industry standards, students can understand how the principles of mechanics apply in a real industrial context. S. Syahril et.al. [79], J. Zhang et.al. [80], H. Suswanto

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et.al. [81], M.D.C. Granado-Alcón et.al. [82], stated that the project-based learning model integrated with industry can improve the competence of information technology skills. The statement is supported by V.J. Llorent et. al. [83], and A.M. Al-Abdullatif, A.A. Gameil [84], that through the completion of industry-standard projects or products, students have the opportunity to interact with various tools, platforms and information technology commonly used in the industrial world. This learning activity equips students with practical and technical skills in operating, maintaining, and utilising various solutions using information technology.

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The i-SDPL model has several limitations that can affect its effectiveness. One of the main challenges is the limited collaboration with industry, especially for schools that do not have easy access to relevant companies. This can be overcome by building a wider network of partnerships through internship programmes, curriculum cooperation and industry visits. In addition, limited resources and infrastructure in some schools are also an obstacle in implementing this model. Solutions that can be applied are the utilisation of simulation technology, cooperation with companies for access to industrial facilities, and procurement of equipment through educational grants.

On the other hand, students' level of independence in learning varies, which can affect the smooth running of their projects. To overcome this, initial training on project management, more intensive guidance from teachers and industry mentors, and periodic evaluations are needed to ensure students' progress. In addition, the evaluation of competency standards is also a challenge due to differences in industry standards that may affect the objectivity of the assessment. Therefore, the development of a standardised assessment rubric with the industry is a solution to ensure a more accurate evaluation and in accordance with the needs of the world of work. An explanation of these limitations and their solutions can be included in the Discussion section to provide insight into the challenges of i-SDPL implementation and strategies to improve its effectiveness.

Conclusion

The i-SDPL learning model is an innovative approach derived from the Project-Based Learning (PjBL) framework. The development of this model stems from a comprehensive needs analysis and feedback from industry experts and practitioners. The distinguishing feature of the i-SDPL model is the integration of industry involvement at every stage of the learning process, including preparation, implementation, and evaluation. Moreover, the i-SDPL model is executed in a blended format, combining learning experiences in vocational high schools (VHS) and industry settings. The industry component is designed to acquaint students with the professional work environment at an early stage.

The i-SDPL learning model has demonstrated its efficacy in enhancing competencies in attitude, knowledge, and work skills through two trial implementations. The implementation of the model is intended to benefit not only students but also teachers. For educators, the i-SDPL model serves as a mechanism to update and expand their knowledge in line with current industry advancements.

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F.A. Ghozali – data analysis, writing a final draft, text editing.

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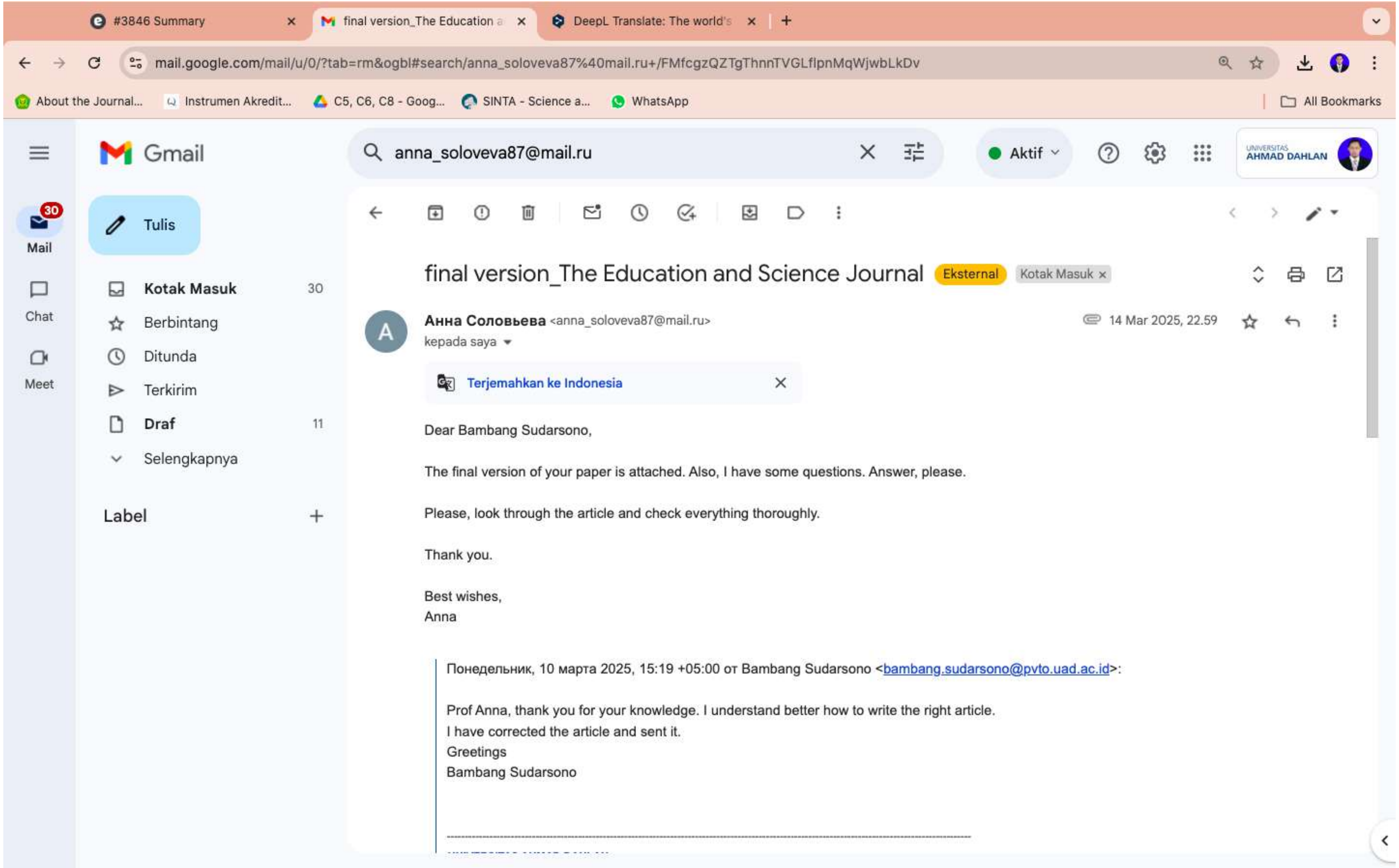
F. ROUND 4 (REVIEW 4)

HASIL CATATAN DAN PERBAIKAN

Round 4 (14 Maret 2025)			
No	Catatan	Perbaikan	Halaman
1	Mengubah Judul " Integrated industry Self-Design Project Learning model: an impactful approach to enhancing job readiness for vocational students"	Improving student readiness for future professional activities: the Self-Design Skills Learning Model (i-SDPL)	1
2	Menambah dan menjelaskan kontribusi penulis	has been corrected research methodology, validation of methodological procedures, developing work readiness instruments, writing the final draft, editing the text	2



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Анна Соловьева <anna_soloveva87@mail.ru>
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Dear Bambang Sudarsono,

The final version of your paper is attached. Also, I have some questions. Answer, please.

Please, look through the article and check everything thoroughly.

Thank you.

Best wishes,
Anna

> Понедельник, 10 марта 2025, 15:19 +05:00 от Bambang Sudarsono <bambang.sudarsono@pvto.uad.ac.id>:
>
> Prof Anna, thank you for your knowledge. I understand better how to write the right article.
> I have corrected the article and sent it.
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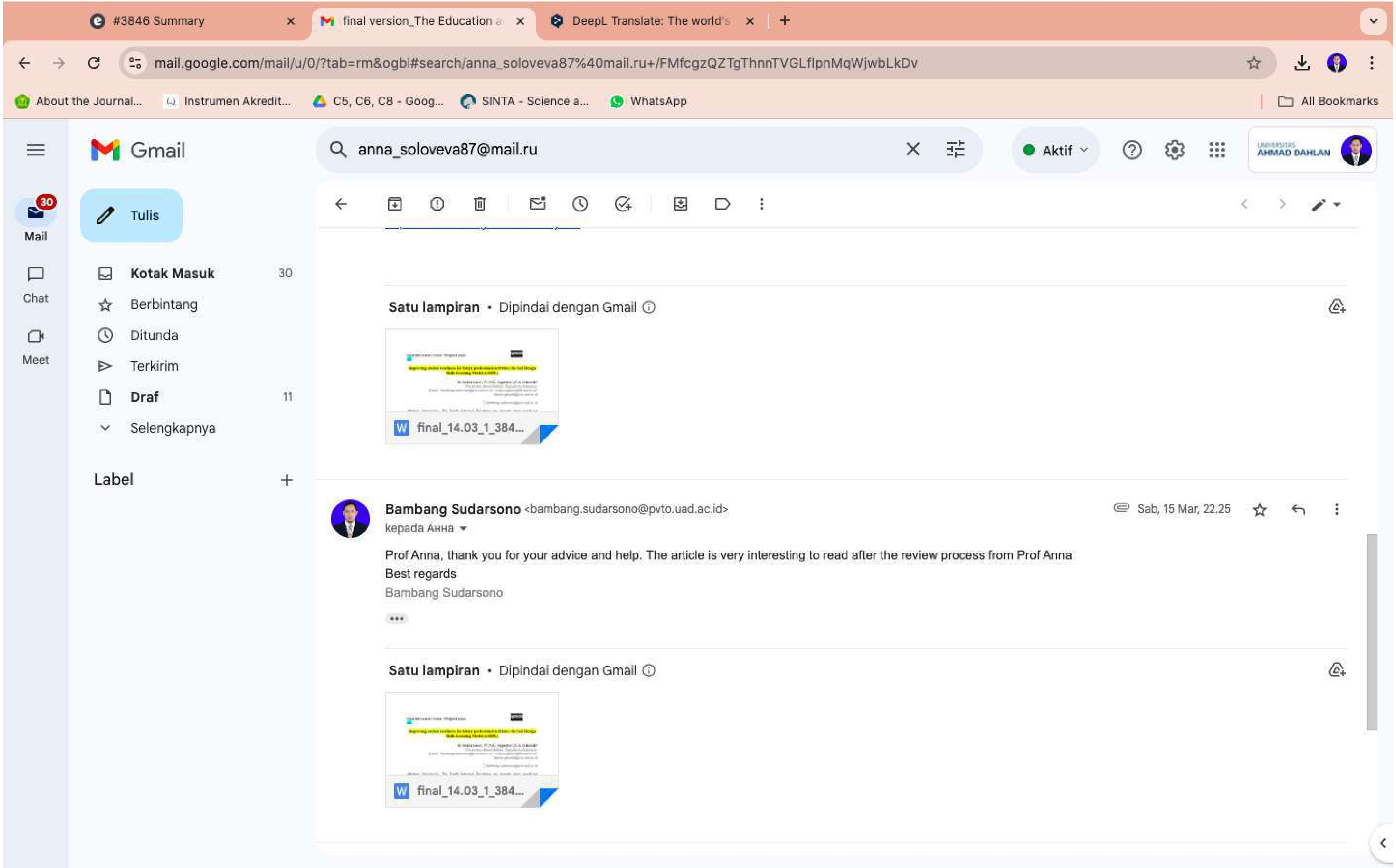
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HASIL ARTIKEL YANG DIPERBAIKI
ROUND 4

Оригинальная статья / Original paper
doi:

Improving student readiness for future professional activities: the Self-Design Skills Learning Model (i-SDPL)

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Commented [MOU2R1]: Yes, I agree. Very good title. Thank you

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Abstract. *Introduction.* The Fourth Industrial Revolution has brought about significant changes in both the economy and education. This study introduces a tailored self-design training model specific to Indonesia's industries for students. *Aim.* The present research *aims* to develop a learning model that is product-oriented and tailored to meet the needs of the industry. Additionally, it seeks to evaluate the model's effectiveness in enhancing the readiness of vocational high school (VHS) students. *Methodology and research methods.* The study employed various testing methods, including interviews, questionnaires, and practical performance assessments. *Results and scientific novelty*. The developed i-SDPL model integrates the learning experiences from VHSs with an industry component aimed at familiarising students with the professional environment of enterprises. This model emphasises student independence in the development and implementation of industry projects. The integration with industry within the model offers students access to the latest technologies and practical knowledge that may not always be available in an academic setting. The advantages of this model include active student participation in enterprise operations, training based on real products, and a comprehensive enhancement of both technical competencies and soft skills compared to traditional methods. The effectiveness of the i-SDPL model is evaluated based on three main competency aspects, each with clear indicators and criteria. The i-SDPL model has demonstrated its effectiveness in enhancing attitude, knowledge, and skills competency among 136 students across two trial implementations. *Scientific novelty.* An original i-SDPL model has been developed to ensure the integration of vocational education programmes with the specific needs of various industries. *Practical significance*. The widespread adoption of the i-SDPL model will further enhance partnerships between vocational education institutions and industry. The findings of this study are not only pertinent to the VHS system in Indonesia but can also serve as a valuable guide for vocational education institutions in other countries facing similar challenges.

***Keywords*:** industry-integrated self-design project learning (i-SDPL), vocational students, job readiness

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Повышение готовности студентов к будущей профессиональной деятельности: модель обучения навыкам самостоятельного проектирования (i-SDPL)

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Аннотация. *Введение.* Четвертая промышленная революция привела к серьезным изменениям как в экономике, так и в сфере подготовки кадров. Исследование представляет вариант модели обучения студентов самостоятельному проектированию для конкретной отрасли промышленности Индонезии. *Цель* исследования – разработка модели обучения, основанной на продукте и соответствующей потребностям отрасли, а также оценка ее эффективности в повышении готовности к работе студентов профессионально-технических училищ (VHS). *Методология и методы исследования.* В исследовании применялись тестовые методы с использованием таких инструментов, как интервью, анкетирование и практические тесты эффективности. *Результаты*. Разработанная модель i-SDPL объединяет опыт обучения в академической среде профессионально-технических училищ (VHS) с отраслевым компонентом, предназначенным для ознакомления студентов с профессиональной средой на предприятиях. Данная модель делает упор на самостоятельность студентов в разработке и реализации отраслевых проектов. Интеграция с промышленностью в рамках модели предоставляет студентам возможность получить доступ к новейшим технологиям и практическим знаниям, которые не всегда доступны в академической среде. Преимущества модели заключаются в активном участии студентов в работе предприятий, обучении на основе реальных продуктов и комплексном укреплении технической компетентности и мягких навыков по сравнению с традиционными методами. Эффективность модели i-SDPL оценивается на основе трех основных аспектов компетентности, каждый из которых имеет четкие показатели и критерии. Представленная модель обучения i-SDPL продемонстрировала свою эффективность в повышении компетентности в области отношения к делу, знаний и трудовых навыков у 136 студентов в ходе двух пробных внедрений. *Научная новизна.* Разработана оригинальная модель i-SDPL, позволяющая обеспечить интеграцию образовательных программ профессионального образования с потребностями конкретных отраслей промышленности. *Практическая значимость.* Широкое внедрение модели i-SDPL будет способствовать дальнейшему укреплению партнерских отношений между учреждениями профессионального образования и промышленностью. Результаты исследования не только актуальны для системы VHS в Индонезии, но и могут служить ориентиром для учреждений профессионального образования в других странах, сталкивающихся с аналогичными проблемами.

Ключевые слова: отраслевое обучение проектам самостоятельного проектирования (i-SDPL), студенты профессионально-технических училищ, готовность к работе

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Introduction

The Fourth Industrial Revolution, known as Industry 4.0, has brought about major changes in various sectors, including the world of work. In this era, the skills required are no longer limited to technical abilities, but also include soft skills such as critical thinking, creativity, and the ability to collaborate [1, 2]. Vocational high schools (VHSs) in Indonesia aim to produce a workforce that is competent and ready to face the world of work [3, 4, 5]. Therefore, adjustments are needed in the curriculum, learning methods, and competency standards to suit industry needs. However, there is still a gap between the world of education and the world of work, which causes VHS graduates to not be fully prepared to face challenges in the industry.

The Industry-Integrated Self-Design Project Learning (i-SDPL) model is emerging as a potential solution to address these challenges. The i-SDPL model is an extension of the existing SDPL model and emphasises the active involvement of students in designing and implementing relevant projects in learning. The main difference with the current SDPL model is that i-SDPL emphasises the active involvement of students in designing and implementing industry-relevant projects [6, 7]. In this model, students not only learn about theoretical concepts, but also apply their knowledge in real situations. Thus, students can develop technical skills and soft skills that are highly needed in the world of work [1, 8]. One of the advantages of i-SDPL is its ability to provide a more in-depth and contextualised learning experience for students. In their self-designed projects, students have to interact with various stakeholders, including teachers, industry professionals and peers [9, 10]. These interactions not only enrich their learning experience, but also help students build professional networks that can be useful in the future. In addition, students also learn to work in teams, resolve conflicts, and manage time effectively.

Integration with industry in SDPL provides opportunities for students to access the latest technology and practical knowledge that is not always available in an academic environment [11, 12]. Through collaboration with industry, students can keep up with the latest trends, understand market needs, and prepare themselves for upcoming challenges [13, 14]. This is especially important given the rapid changes in technology and the need for a flexible and adaptive workforce. Industry also benefits by being involved in the education process, such as identifying potential workforce candidates and contributing to the development of relevant curricula.

The perceptions of stakeholders, including students, teachers and industry, will be the main focus in assessing the success of this learning model. Students are expected to provide feedback on their learning experience, mastery of technical and soft skills, and the relevance of the project to industry needs. Teachers will provide perspectives on implementation challenges, benefits for improving the quality of learning, and the impact on teaching methods applied in the classroom. Meanwhile, the industry will assess students' work readiness, identify skills gaps, and provide recommendations to enhance the integration of SDPL with evolving industry demands.

In addition, this research will also assess how SDPL can be adapted and implemented in different contexts. Given the diversity of VHSs in Indonesia, it is important to understand the factors that may influence the successful implementation of this model, such as support from school Yes, I agree. Very good title. Thank you management, availability of resources, and linkages with industry. This study will explore various strategies that can be used to overcome these challenges, as well as evaluate how this model can be integrated with existing educational programmes.

With the growing need for a ready and competent workforce, it is important to evaluate and update existing learning approaches. Industry-Integrated SDPL (i-SDPL) offers an attractive model to improve the work readiness of vocational students [15]. The i-SDPL model emphasises student independence in designing and implementing industry-based projects, with direct integration in every stage of learning to improve work readiness. Its advantages lie in active industry involvement, real product-based learning, and holistic strengthening of technical competence and soft skills compared to conventional methods.

The performance of the i-SDPL model is evaluated based on three primary competency aspects, each with clear indicators and criteria: (a) Attitude. This is assessed through rigour, teamwork, diligence, discipline, as well as creativity and innovation, which reflect students' preparedness for a real work environment. (b) Knowledge. This is measured by the technical understanding and material knowledge required by the industry, ensuring that students master both the theory and its practical applications. (c) Skills. This encompasses mechanical and information technology skills, which are fundamental to industrial practice and the utilisation of modern technology [16, 17].

Overall, this research aims to provide a comprehensive insight into the development of an Industry-Integrated Self-Design Project Learning Model in VHS. By examining various aspects of this model, it is hoped that ways can be found to improve its effectiveness and provide maximum benefits for students. The results of this research are not only relevant for VHSs in Indonesia, but can also serve as a reference for vocational education institutions in other countries facing similar challenges.

Literature Review

Vocational High Schools (VHS) serve as educational institutions designed to prepare graduates for immediate entry into the workforce in their respective fields of expertise [18, 19]. VHS play a crucial role in meeting the labor demands of various industrial sectors. Consequently, the quality of VHS graduates directly impacts industrial productivity. According to S. Sukardi, W. Wildan, A. Subhani [15] and V. R. Palilingan, R. R. Oroh, M. S. S. Tumanduk et al. [20], well-prepared VHS graduates can seamlessly transition into the workforce, contributing effectively to their respective industries and enhancing overall productivity.

However, data from the Central Bureau of Statistics indicate that VHS graduates constitute the highest proportion of unemployed individuals, accounting for 9.6% of the total unemployment rate [21]. This high unemployment rate among VHS graduates can be attributed to several factors, with the primary issue being their level of job readiness [22]. Many graduates lack the necessary skills and practical experience demanded by employers, leading to a significant gap between education and employment. S. A. Rodzalan, N. N. Mohd Noor, N. H. Abdullah et al. [23] and W. Schulz, H. Solga, R. Pollak [24] stated that addressing this issue requires a comprehensive approach to improve the vocational training curriculum, incorporate industry-specific skills, and provide real-world experience to enhance the employability of VHS graduates.

In the study conducted by A. Prianto, W. Winardi, U. N. Qomariyah, it is established that the readiness to enter the workforce among graduates of VHS is formed through a comprehensive learning process that includes theoretical instruction, practical training, and industry exposure [25]. Vocational high schools have been progressively enhancing the quality of their education by integrating advanced educational methods and updating their curricula to meet the evolving demands of the job market [25, 26]. These efforts encompass a variety of initiatives, including the adoption of modern teaching techniques, the improvement of learning facilities, and the use of technology-enhanced learning tools. Despite these advancements, the issue of high unemployment rates among VHS graduates remains a significant challenge, requiring further strategic interventions.

A critical component of addressing this challenge is the establishment of robust partnerships between vocational high schools and industries [27]. D. W. Drewery, T. J. Pretti and D. Church noted that such collaborations are essential for aligning the educational outcomes of VHS students with the specific skills, knowledge, and attitudes required by employers [28]. By engaging directly with industries, vocational schools can ensure that their curricula are not only relevant but also forward-looking, preparing students for current and future job market demands [29, 30]. These partnerships facilitate the exchange of valuable insights and allow for the adaptation of teaching methodologies to better meet industry standards. As pointed out by D. Borah, K. Malik, S. Massini [31] and L. Underdahl, P. Akojie, M. Agustin Magabo et al. [32], industry involvement in the education process can provide students with practical experience and real-world exposure, further enhancing their readiness for employment.

I. García-Martínez, M. Montenegro-Rueda, E. Molina-Fernández et al. [33] and S. U. Nsanzumuhire, W. Groot [34] reported that a systematic approach is required to effectively implement these industry-school collaborations. This includes conducting comprehensive needs analyses to identify the specific competencies demanded by various sectors, developing detailed task descriptions that outline the expected job roles, and establishing clear competency standards that serve as benchmarks for student performance. Additionally, creating rigorous assessment procedures is crucial for evaluating whether students have acquired the necessary skills and knowledge. These assessments should be designed in consultation with industry experts to ensure their relevance and accuracy. Through these collaborative efforts, vocational high schools can produce graduates who are not only academically proficient but also possess the practical capabilities and professional attitudes required to thrive in the workforce [35, 36].

S. McGrath, S. Yamada [37], P. S. Rebia, Suharno, A. G. Tamrin et al. [38] and D. Rachmawati, S. Suharno, R. Roemintoyo [39] highlighted the pivotal factor contributing to the effective cultivation of work readiness among graduates of VHS, which resides in the proactive engagement of the industry in establishing competency benchmarks for VHS graduates, encompassing attitudes, knowledge, and skills. The main criterion for the implementation of VHS is the formation of competencies with standardisation in accordance with the needs of the world of work. L. Jie, T. Choicharoen, S. Juithong identified Self-Design Project Learning (SDPL) as a pedagogical methodology garnering increasing attention in vocational education [40]. SDPL stands out as a pedagogical model deemed suitable for adoption within vocational education settings. The fundamental aim of the SDPL framework is to align the caliber of vocational graduates with industry exigencies [41, 42]. SDPL is characterised by students acquiring proficiency in attitude, knowledge, and work skills through their engagement with products or projects. Much of the research conducted by F. N. Fauziah, K. Saddhono, E. Suryanto [43], N. B. Muliawan, I. A. Sulistijono [44], I. Tejawiani, I. Lastriyani, L. Lidiawati et al. [45] and M. A. Almulla [46] has focused on identifying the SDPL framework comprises seven distinct stages, namely: (a) Product/Project Planning; (b) Implementation; (c) Inquiry and Development; (d) Collaboration; (e) Evaluation; (f) Presentation; and (g) Reflection.

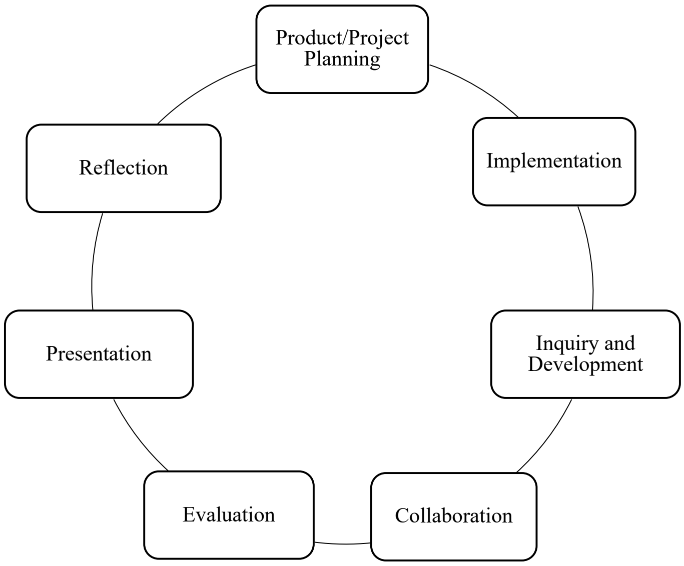


Fig. 1. Stages of the Self-Design Project Learning (SDPL) model

The i-SDPL (Industry-Integrated Self-Design Project Learning) model represents a refinement of traditional Project-Based Learning (PjBL), aimed at addressing the inherent limitations observed in the standard SDPL approach. Recent scholarly investigations, as documented by R. Zhang, J. Shi, J. Zhang [47], V. L. Hariyanto, R. Hidayah, G. N. I. Putra Pratama et al. [48], and P. Nilsook, P. Chatwattana, T. Seechaliao [49], have underscored deficiencies primarily pertaining to collaborative dynamics and the degree of industrial engagement within the educational milieu. These shortcomings have prompted a concerted effort to reconceptualise the SDPL framework, thereby fostering a more symbiotic relationship between academia and industry.

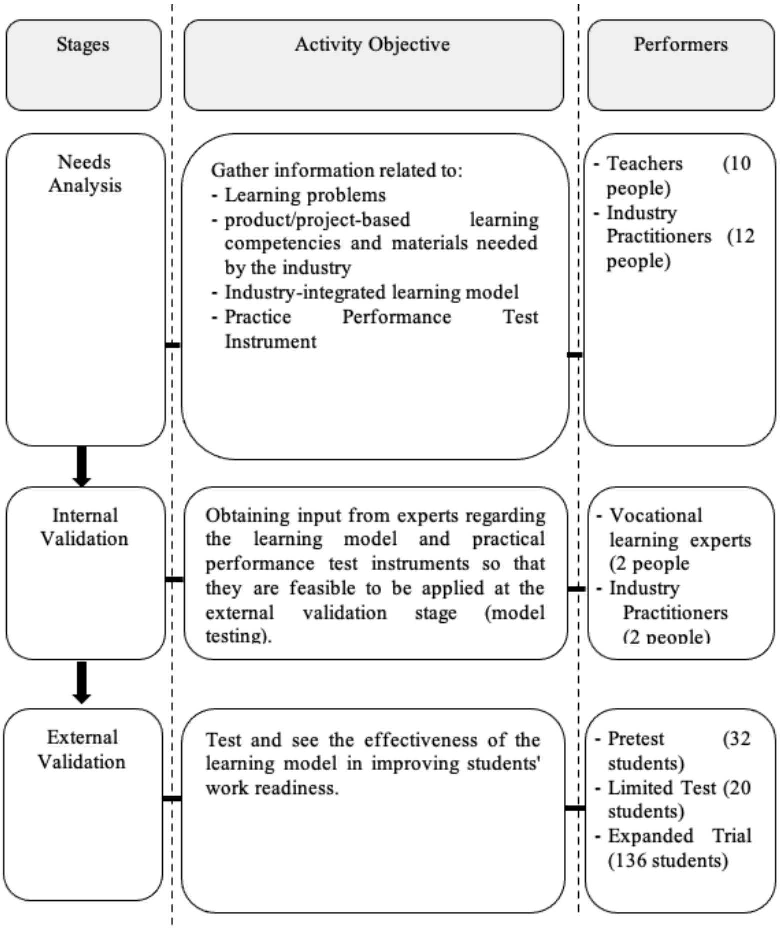
The integration of i-SDPL with industrial imperatives is multifaceted, encompassing several key facets. Firstly, it necessitates the alignment of educational objectives with the dynamic demands of contemporary industries. This alignment ensures that curricular content is not only relevant but also responsive to the evolving needs of the professional landscape. Secondly, the collaborative partnership between educators and industry stakeholders assumes paramount significance. By fostering close ties between these two spheres, i-SDPL endeavours to bridge the gap between theoretical knowledge and practical application, thereby imbuing students with a holistic understanding of their chosen vocation. Finally, the utilisation of industrial infrastructure serves to immerse students in an authentic work environment, thereby providing firsthand exposure to the challenges and nuances of their respective industries.

Ultimately, the overarching goal of integrating the i-SDPL model with industry is to enhance the vocational preparedness of students enrolled in Vocational High Schools (VHS) while simultaneously mitigating the incidence of post-graduation unemployment. Through a synergistic blend of academic rigor and real-world applicability, i-SDPL seeks to empower students with the requisite skills and competencies to thrive in an increasingly competitive job market. Moreover, by fostering a culture of collaboration and partnership between academia and industry, i-SDPL not only serves the immediate interests of students but also contributes to the broader socio-economic development of the communities it serves [50, 51, 52, 53].

Methodology, Materials and Methods

This study employed J. D. Richey's and R. C. Klein's research and development design, comprising three distinct stages of inquiry [54]. The stages of the research and development of the Industry-Integrated Self-Design Project Learning model are divided into 3 stages. These stages are needs analysis, internal validation and external validation. The needs analysis stage aims to explore information about the condition of learning in VHS, what aspects of competence are needed by the industry and VHS and what materials are currently needed by the industry and can be integrated with a product / project-based learning model. This stage involves 10 teachers and 12 industry practitioners to ensure that learning needs are accurately identified and aligned with industry requirements.

The Internal Validation stage aims to obtain feedback from experts to ensure that the learning model and Practical Performance Test instruments are suitable for application in the External Validation stage. This stage involves 2 vocational education experts and 2 industry practitioners who assess the feasibility of the developed models and instruments. Their input is used to refine and adjust the models before wider testing. The External Validation stage focuses on evaluating the effectiveness of the learning model in enhancing students' work readiness. This process involves a series of tests and trials, beginning with a pretest involving 32 students, followed by a limited test with 20 students, and culminating in a broader trial with 136 students. This phased approach allows for a thorough evaluation of the learning model, from small groups to larger cohorts, ensuring its effectiveness and reliability in an educational setting. The sequential progression of these research stages is illustrated in Figure 2.



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ig. 2. Research and development procedures

The data collection methodologies employed in this study encompassed both test-based and non-test-based approaches. Non-test methodologies comprised interviews and questionnaires. The test-based methodology entailed a practical performance examination. Interviews were conducted through focused group discussions to glean insights into learning impediments, competencies, and the requisite product/project-oriented learning materials essential for industry integration.

Table 1

The internal validation instrument grids

No	Criteria	Assessment indicators
1	Relevance	The learning model is relevant to the learning objectives to be achieved
2	Necessity	The learning model is appropriate to the needs and characteristics of students.
3	Clarity	The instructions and steps in the learning model are clearly presented and easy to understand.
4	Readability	The language used in the learning model is easy to understand by students, teachers and industry practitioners.
5	Applicability	The learning model can be applied in the context of classroom learning
6	Effectiveness	The learning model is effective in improving aspects of student competence
7	Suitability to the curriculum	The learning model is in accordance with the applicable curriculum and is able to support the achievement of basic competencies that have been determined
8	Industry participation	The learning model encourages industry participation

To see the feasibility of the learning model and practical performance assessment instruments, validation and input from experts consisting of vocational education/learning experts and industry practitioners are required. Furthermore, the learning model and practical performance assessment instruments resulting from internal validation are applied to the external validation stage to determine the effectiveness of the learning model in improving students' work readiness. The internal validation instrument grids for experts and learning evaluation instruments can be seen in Table 1 and Table 2, respectively.

Table 2

Learning evaluation instruments

Competencies	Competency aspect
Attitude	Thoroughness
	Teamwork
	Hard work and discipline
	Creativity and innovation
Knowledge	Technical knowledge
	Material knowledge
Skills	Mechanical skills
	Information technology skills

The validity and reliability of the interview, questionnaire, and performance test instruments were assessed through rigorous content validity tests conducted by experts drawn from the realms of vocational learning and industry. Specifically, these experts held positions as car service advisors, ensuring a specialised understanding of the subject matter. Reliability testing, on the other hand, was executed utilising the Cronbach's alpha (α) test, a renowned measure known for its ability to ascertain internal consistency reliably. The outcomes consistently affirmed the instruments' reliability. The assessment instrument for the student practical performance test underwent meticulous development, spearheaded by VHS Automotive Engineering educators, automotive industry practitioners, and vocational learning authorities. Drawing upon the seminal research titled "Development of an Industry-Oriented Experiential Learning (EL+i) Model to Enhance Vocational High School Students' Job Readiness", as delineated in Table 3, the instrument was tailored to suit the exigencies of the study [55] .

Table 3

Categorisation of questionnaires and practical performance tests

Score	**Category**
3.01–4.00	Very effective
2.51–3.00	Effective
2.01–2.50	Less effective
0–2.00	Ineffective

Quantitative data analysis served as the cornerstone for evaluating both the model's feasibility questionnaire instrument and the practical performance assessment instrument, alongside the subsequent analysis of the practical performance test results. This analytical approach facilitated comprehensive categorisation and interpretation of the amassed data.

Research Results

Needs Analysis

The needs analysis stage aims to investigate learning challenges, required competencies, and the product or project-based learning materials necessary for industry integration. Data analysis was conducted through focus group discussions involving participants from vocational high school automotive engineering teachers and automotive industry practitioners. The findings from the needs analysis stage are presented in Table 4, Table 5, and Figure 3. The results indicate that the current industry demands product and project-based learning materials, specifically in the areas of electric vehicle modification, gas and electric welding, and oven painting.

Table 4

Learning problems

No.	Indicators	Vocational school teachers	Industry practitioners
1	Learning Planning	Teachers plan lessons in accordance with the instructions of related agencies; there is no role for industry.	VHSs do not collaborate with industry in lesson planning.
2	Learning Implementation	During this time, the implementation of learning is done by teachers themselves; the role of industry is absent.	VHSs passively collaborate and cooperate with industry in the implementation of learning.
3	Evaluation of Learning	VHS-based evaluation; no industry role.	VHS collaboration with industry is limited to graduation competency tests. Not implemented on every competency indicator required by VHS.
4	Graduate Quality	The quality of graduates is not certified by the industry.	The quality of graduates depends on the results of the VHS process, while industry contributes minimally.

The analysis reveals significant deficiencies in the collaboration between vocational high schools and industry in planning, implementation, evaluation, and graduate quality. The curriculum is developed and implemented unilaterally by vocational high schools without industry participation. Thus, industry involvement is lacking. Evaluation is primarily managed by vocational high schools, with industry participation limited to graduation competency tests, resulting in graduates lacking industry certification. To address these issues, it is recommended to establish partnerships between vocational high schools and industry to co-develop curricula that integrate current industry standards and practices.

Industry professionals should actively participate in teaching and provide practical training, while continuous evaluation involving industry practitioners should be implemented to ensure students meet the required competencies. In addition, certification processes developed in collaboration with industry should validate graduates' skills and knowledge, thereby improving their employability and ensuring vocational education is aligned with current industry standards.

Industry practitioners work together with vocational high schools to play an active role in the planning, implementation, evaluation, certification and sustainability of vocational high school graduates to form competency completeness that meets industry criteria.

Table 5

Competencies required by industry

Competencies	Competency aspect	Description
Attitude	Thoroughness	Ability to perform work with detail and accuracy.
	Teamwork	Ability to work with others in a team, collaborate and support each other to achieve common goals.
	Hard work and discipline	Ability to complete tasks in a timely manner and to a high standard of quality.
	Creativity and innovation	Ability to think beyond predictions, seek new solutions, or improve existing processes.
Knowledge	Technical knowledge	Ability about the principles, concepts, and specific details of a field of technology or science.
	Material knowledge	Understanding of the types of materials, their properties, processing methods and applications in technology, their properties, optimal use, and ways of processing and application in various contexts.
Skills	Mechanical skills	Skills in maintenance and repair of work equipment and field of work.
	Information technology skills	Skills in using software and related technology that supports work processes in industry.

The listed competencies are comprehensive and encompass essential areas for vocational students, particularly those specialising in electric vehicles. Attitude-related competencies prepare students to work effectively and innovate within teams. Knowledge-based competencies provide the theoretical foundation necessary for understanding and applying technical concepts. Skill-related competencies ensure students can perform practical tasks and utilise modern technologies proficiently. Integrating these competencies into vocational education can significantly enhance students' readiness for the workforce, especially in technical and rapidly advancing fields such as electric vehicle technology.

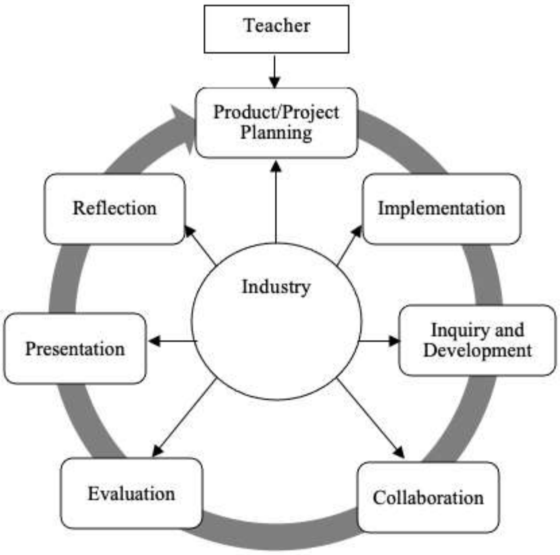

Fig. 3. i-SDPL model from needs analysis (conceptual)

Internal Validation

The internal validation stage aims to determine feasibility and seek input and suggestions from experts regarding the feasibility of practical performance assessment models and instruments, which will be applied at the external validation (trial) stage. Experts involved in the internal validation stage include: (a) vocational learning lecturers with over 15 years of academic experience, automotive competency certificates, and relevant work in automotive engineering, and (b) industry practitioners with over 10 years of experience as service advisors or workshop heads. The results of the internal validation indicate that the practical performance assessment instrument aligns with the measured competencies, rubric criteria, and scoring.

Regarding the stages of developing the i-SDPL learning model, some important points resulting from the internal validation stage are as follows: (a) i-SDPL emphasises collaboration between industry and educators at every stage of the model; (b) implementation of the model is feasible in both vocational schools and industry, taking into account the availability of learning facilities and infrastructure; (c) evaluation occurs in the industry with graduation standards aligned with industry needs. The revised i-SDPL learning model, incorporating feedback from the internal validation stage, is illustrated in Figure 4.

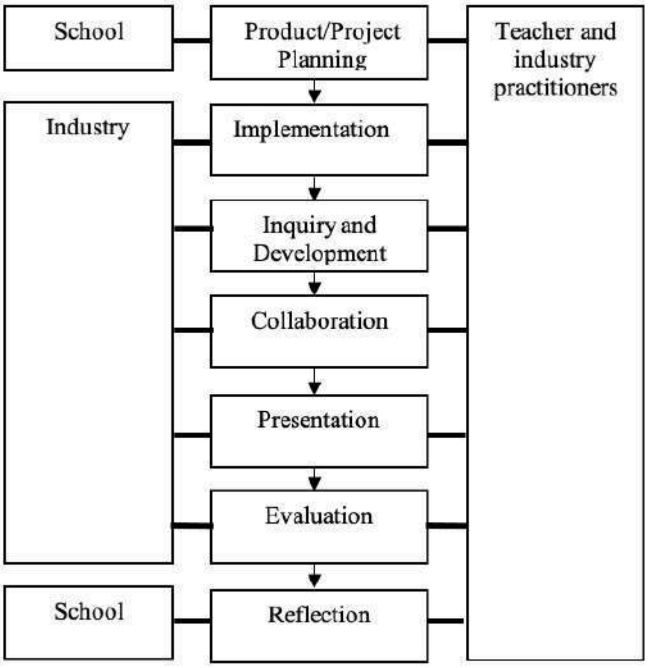

Fig. 4. Implementation of i-SDPL model

The i-SDPL model consists of stages that aim to shape the work readiness of the rest of the vocational school:

- The product/project planning contains activities aimed at establishing clear learning objectives, selecting appropriate projects/products, and scheduling their implementation.
- The implementation stage contains student activities in implementing learning in accordance with the learning plan. Teachers and industry practitioners ensure learning outcomes comply with industry standards. This phase is important for grounding theoretical knowledge in practical application.
- The investigation and development stage encourages students to complete learning tasks according to the knowledge and skills they have acquired.
- The collaboration stage is the stage where students interact directly with industry practitioners to gain experience, knowledge and skills according to the needs of the industrial world.
- The presentation stage contains activities to demonstrate the results of the problem solving process/tasks that have been studied. Here communication will be formed and produce input from other students, teachers and industry practitioners.
- The evaluation stage contains competency tests and feedback that are in line with industry standards.
- The final stage, reflection, allows teachers and industry practitioners to assess learning outcomes and develop further strategies for developing student competencies.

Table 4

Stages of Industry-Integrated Self-Design Project Learning (i-SDPL) model

Model stages	Activities	Time
Product/Project Planning	Industry practitioner and teacher together: - determine learning objectives; - determine the project or product that will be used for learning; - inform students about the work plan and schedule for learning implementation; and - divide the group.	Before learning
Implementation	Students start practising and working according to the projects planned by teachers and industry practitioners.	According to industry

	Industry practitioners and teachers together provide guidance to students when needed.	standards
Inquiry and Development	Students complete a project/product.	
	Student apply he attitudes, knowledge and skills gained from learning.	
	Industry practitioners and teachers together provide guidance to students when needed.	
Collaboration	Students interact with industry practitioners who are experienced in completing projects/products.	
Presentation	Students present the results of the project/product that is done.	10 minutes/group
Evaluation	Teachers and industry practitioners evaluate student progress on a regular basis.	As per industry standard
	Teachers or industry practitioners conduct competency tests.	
	Teachers and industry practitioners summarise and provide feedback to students.	
Reflection	Teachers and industry practitioners reflect on learning outcomes and plan steps for student competency development.	At the end of the lesson

External Validation

The external validation stage is divided into two: limited trial and extended trial stages. The purpose of external validation is to determine the effectiveness of the i-SDPL model in improving the work readiness of vocational students. External validation activities began with a pretest involving 32 students of VHS Muhammadiyah 2 Tempel. The subject matter tested was welding with a motorcycle chain cover project. The limited trial was conducted at VHS Muhammadiyah 1 Salam Magelang involving 20 students who studied welding with a toolbox project. Meanwhile, the extended trial was conducted at SMK Muhammadiyah 1 Salam and SMK Muhammadiyah Pakem, involving 136 students from the Automotive Engineering Department.

The analysis of the table indicates significant improvements across various categories attitude, knowledge, and skills from pretest to posttest. In the attitude category, there was a notable increase in creativity and innovation, with scores rising from 1.4 in the pretest to 3.6 in the posttest. Although some categories, such as conscientiousness and hard work and discipline, experienced a decline during the trials stage, both showed significant improvement in the posttest. The knowledge category also demonstrated a positive upward trend, with material knowledge increasing from 1.6 in the pretest to 3.6 in the posttest. Similarly, the skills category exhibited growth, with information technology skills improving from 1.4 in the pretest to 3.4 in the posttest.

Overall, these results suggest that the implemented programme or intervention was successful in enhancing participants' attitudes, knowledge, and skills, despite some fluctuations during the trials stage. This indicates that, despite initial challenges, participants were able to overcome and significantly improve their abilities through the learning process or intervention conducted. The results of the external validation stage can be seen in Figure 5.

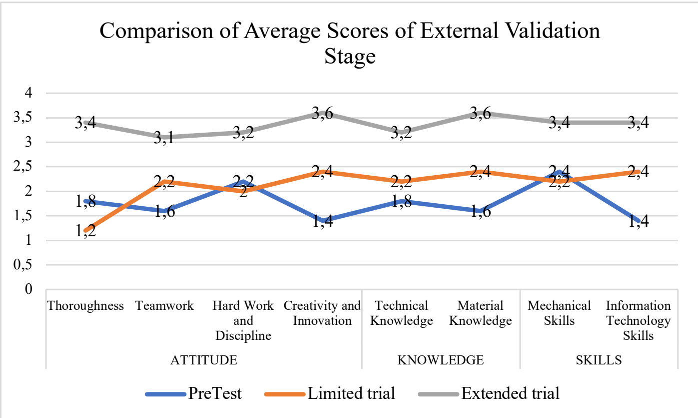

Fig. 5. Comparison of average scores of external validation stage

Results and Discussion

According to I. Tejawiani, I. Lastriyani, L. Lidiawati et al. [45], D. Guile, C. Spinuzzi [56], and L. Youyou, A. C. Kit [57], the Industry-Integrated Self-Design Project Learning (i-SDPL) model, derived from the Project Based Learning (PjBL) framework, emphasises the development of student competencies through direct engagement with industry-related projects and products. This model integrates theoretical and practical learning, fostering a holistic development of attitudes, knowledge, and skills. Key characteristics of the i-SDPL model include its collaborative approach, where educators and industry practitioners work together to guide students. The curriculum is aligned with industry standards, ensuring that the competencies students acquire are relevant and up-to-date with current industrial demands. Furthermore, the model includes rigorous stages of implementation and evaluation, conducted within industrial settings, which immerse students in real-world work environments. This not only bridges the gap between classroom learning and industry practice but also facilitates a smoother transition for students into the workforce.

According to C. Marnewick [58], H. Yudiono, S. Maulana, M. B. R. Wijaya et al. [59], and G. Pan, P.-S. Seow, V. Shankararaman et al. [60], in the i-SDPL learning model, the integration of project- and product-based learning with industry standards is essential in shaping students' competencies to meet industry needs. By working on real industrial projects, students gain practical experience and develop skills that can be directly applied in their future careers. This experiential learning approach not only improves technical proficiency, but also encourages critical thinking, problem-solving and collaboration skills. Exposure to the industrial climate plays an important role in preparing students for the professional environment by enhancing their understanding of industrial processes and work culture. This comprehensive exposure helps develop the character and work readiness of vocational high school (VHS) students, making them more adaptable and able to face the challenges of the modern industrial landscape. The i-SDPL model, therefore, represents a significant advancement in vocational education by ensuring that students are not only academically proficient but also industry-ready.

According to A. Saepudin [61], the i-SDPL learning model has been shown to be highly effective in improving work readiness across multiple dimensions, including attitude, knowledge and skills. The model significantly improves competence in the attitude of rigour. The statement is supported by H. B. Issa and A. Khataibeh [62], who state that project-based learning is a core component of the i-SDPL model that emphasises the final quality of the product. To achieve a high-quality product, students must pay careful attention to every detail and ensure that each step is done carefully, thus consistently developing attitudinal competence in the aspect of rigour. In addition, G. Aydın, O. Mutlu [63] and U. Usmeldi, R. Amini [64], stated that the i-SDPL learning model is an effective method to foster competence in teamwork. Student collaboration/cooperation in producing products/projects forms student competence in discussion and provides different knowledge.

According to Z. Zen, Reflianto, Syamsuar et al. [65], L. Zhang, Y. Ma [66] and T. Q. Tran, T. N. P. Tran [67], work competence and discipline refer to a person's ability to complete tasks on time with high quality standards. Through the application of the i-SDPL learning model by producing projects or products, students can create work that meets industry standards, which emphasise completeness, efficiency and perfection. By applying i-SDPL consistently, an optimal attitude of hard work and discipline will be formed. The next attitude competency is creativity and innovation. According to S. Hanif, A. F. C. Wijaya, N. Winarno [68], S. K. Ummah, A. Inam, R. D. Azmi [69], and A. Ahmad, B. Jabu [70], the application of i-SDPL will strengthen students' creativity and innovation attitudes. In the process of making products, students repeatedly receive input/direction from industry practitioners and teachers. The process encourages students to always innovate, looking for new ways to improve the quality of the products they produce, so that their creativity and innovation competencies are growing.

Motivational factors for all participants in the i-SDPL model include aspects from students, teachers, and industries involved in the learning process. The i-SDPL learning model stimulates students to understand and apply concepts and theories in product manufacturing. The question is supported by Syahril, Purwantono, R. E. Wulansari et al. [71] and M. H. Shin [72], that through the i-SDPL learning model, students more easily understand the relevance and importance of technical knowledge in practical applications. Not only that, this model also facilitates students to experience firsthand the process and challenges of completing a project or product. This activity encourages students to develop technical skills from planning, implementation, to evaluation. In addition, the i-SDPL learning model improves students' material knowledge competence. This is supported by research conducted by N. Wijayati, W. Sumarni, S. Supanti [73], E. C. Miller, J. S. Krajcik [74], and M. Nasir, R. Fakhrunnisa, L. R. Nastiti [75], which showed that learning with the i-SDPL model can shape students' attitudes, knowledge, and work skills as a whole. Through this model, students not only understand the theory, but can also directly observe how these concepts are applied in making real projects or products. The integration of product-based learning models with industry allows students to gain practical experience in the use and processing of materials, so that they are better prepared to face challenges in the world of work.

For teachers, motivation comes from their role as facilitators who not only teach theory but also guide students in industry-based projects. This model allows teachers to update their insights through co-operation with industry as well as develop more innovative and effective learning methods. In addition, students' success in producing quality projects is a source of satisfaction for educators. For the industry, involvement in SDPL is an opportunity to get a more prepared and skilled workforce candidate according to the company's needs. By participating in the design and evaluation of projects, industries can ensure that graduates have competencies that meet their standards. In addition, this model also helps the industry to build close relationships with educational institutions, which can lead to wider cooperation in the future.

Mechanical skills competence refers to a person's practical ability to understand, maintain, repair and operate machine tools and components. The i-SDPL learning model is developed in accordance with industry needs and standardisation. Through the application of the model, students get the opportunity to apply the theory and concepts of machining in making projects or products. This question is in accordance with the results of research from W.

Kurniawan, A. Budiono [76], H. Maksum, W. Purwanto [77], C. Y. Chao, Y.-C. Li, M.-S. Hour et al. [78], and S. Syahril, R. A. Nabawi, D. Safitri [79], who stated that by working according to industry standards, students can understand how the principles of mechanics apply in a real industrial context. S. Syahril, R. A. Nabawi, D. Safitri [79], J. Zhang, W. Wu, H. Li [80], H. Suswanto, A. Hamdan, R. R. Mariana et al. [81], M. D. C. Granado-Alcón, D. Gómez-Baya, E. Herrera-Gutiérrez et al. [82], stated that the project-based learning model integrated with industry can improve the competence of information technology skills. The statement is supported by V. J. Llorent, A. L. González-Gómez, D. P. Farrington et al. [83], and A. M. Al-Abdullatif, A. A. Gameil [84], that through the completion of industry-standard projects or products, students have the opportunity to interact with various tools, platforms and information technology commonly used in the industrial world. This learning activity equips students with practical and technical skills in operating, maintaining, and utilising various solutions using information technology.

The i-SDPL model has several limitations that can affect its effectiveness. One of the main challenges is the limited collaboration with industry, especially for schools that do not have easy access to relevant companies. This can be overcome by building a wider network of partnerships through internship programmes, curriculum cooperation and industry visits. In addition, limited resources and infrastructure in some schools are also an obstacle in implementing this model. Solutions that can be applied are the utilisation of simulation technology, cooperation with companies for access to industrial facilities, and procurement of equipment through educational grants.

On the other hand, students' level of independence in learning varies, which can affect the smooth running of their projects. To overcome this, initial training on project management, more intensive guidance from teachers and industry mentors, and periodic evaluations are needed to ensure students' progress. In addition, the evaluation of competency standards is also a challenge due to differences in industry standards that may affect the objectivity of the assessment. Therefore, the development of a standardised assessment rubric with the industry is a solution to ensure a more accurate evaluation and in accordance with the needs of the world of work. An explanation of these limitations and their solutions can be included in the Discussion section to provide insight into the challenges of i-SDPL implementation and strategies to improve its effectiveness.

Conclusion

The i-SDPL learning model is an innovative approach derived from the Project-Based Learning (PjBL) framework. The development of this model stems from a comprehensive needs analysis and feedback from industry experts and practitioners. The distinguishing feature of the i-SDPL model is the integration of industry involvement at every stage of the learning process, including preparation, implementation, and evaluation. Moreover, the i-SDPL model is executed in a blended format, combining learning experiences in vocational high schools (VHS) and industry settings. The industry component is designed to acquaint students with the professional work environment at an early stage.

The i-SDPL learning model has demonstrated its efficacy in enhancing competencies in attitude, knowledge, and work skills through two trial implementations. The implementation of the model is intended to benefit not only students but also teachers. For educators, the i-SDPL model serves as a mechanism to update and expand their knowledge in line with current industry advancements.

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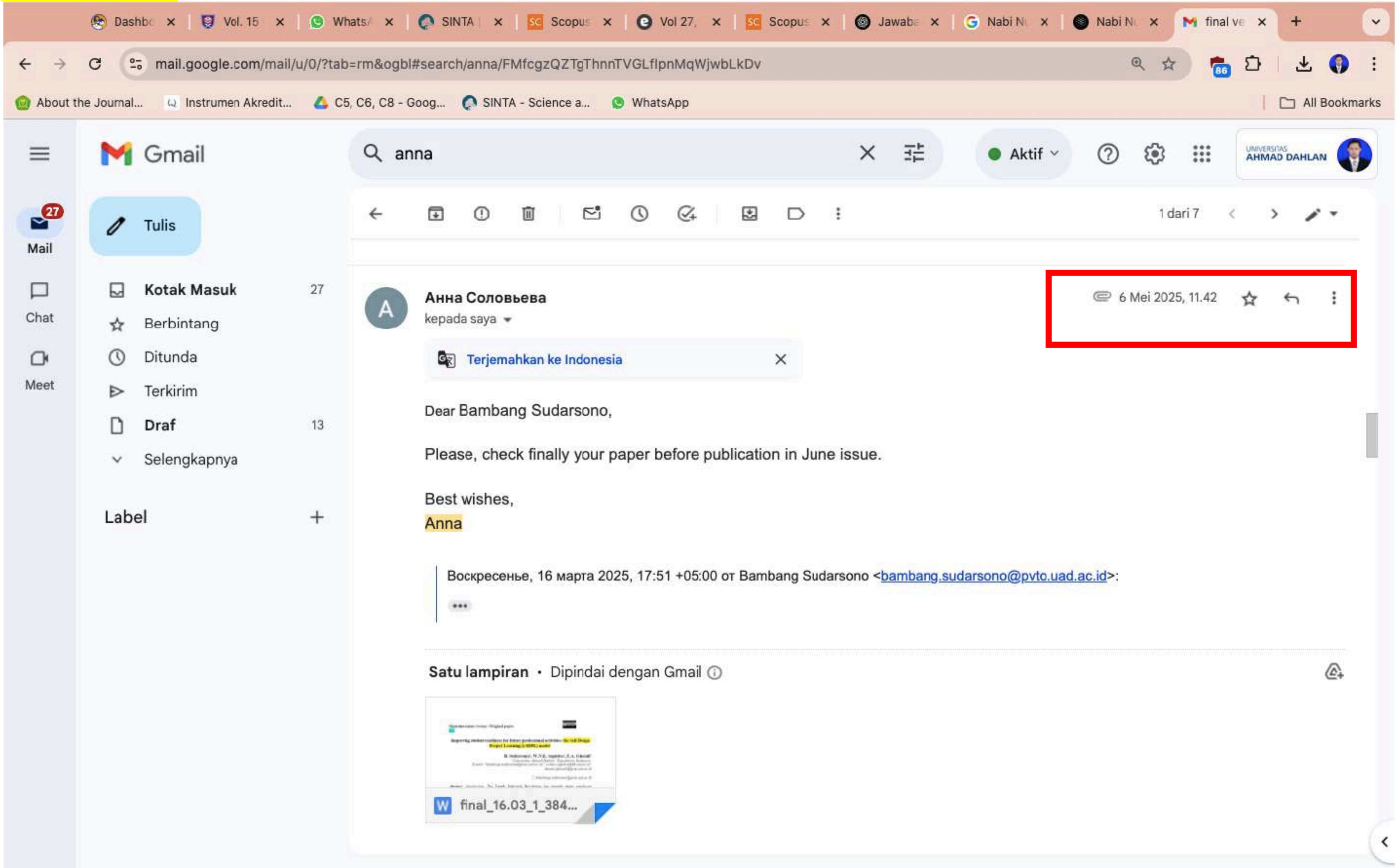
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Improving student readiness for future professional activities: the Industry-Integrated Self-Design Project Learning (i-SDPL) model

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Abstract. *Introduction.* The Fourth Industrial Revolution has brought about significant changes in both the economy and education. This study introduces a tailored self-design training model specific to Indonesia's industries for students. *Aim.* The present research *aims* to develop a learning model that is product-oriented and tailored to meet the needs of the industry. Additionally, it seeks to evaluate the model's effectiveness in enhancing the readiness of vocational high school (VHS) students. *Methodology and research methods.* The study employed various testing methods, including interviews, questionnaires, and practical performance assessments. *Results and scientific novelty*. The developed Industry-Integrated Self-Design Project Learning (i-SDPL) model integrates the learning experiences from VHSs with an industry component aimed at familiarising students with the professional environment of enterprises. This model emphasises student independence in the development and implementation of industry projects. The integration with industry within the model offers students access to the latest technologies and practical knowledge that may not always be available in an academic setting. The advantages of this model include active student participation in enterprise operations, training based on real products, and a comprehensive enhancement of both technical competencies and soft skills compared to traditional methods. The effectiveness of the i-SDPL model is evaluated based on three main competency aspects, each with clear indicators and criteria. The i-SDPL model has demonstrated its effectiveness in enhancing attitude, knowledge, and skills competency among 136 students across two trial implementations. *Scientific novelty.* An original i-SDPL model has been developed to ensure the integration of vocational education programmes with the specific needs of various industries. *Practical significance*. The widespread adoption of the i-SDPL model will further enhance partnerships between vocational education institutions and industry. The findings of this study are not only pertinent to the VHS system in Indonesia but can also serve as a valuable guide for vocational education institutions in other countries facing similar challenges.

Keywords: industry-integrated self-design project learning (i-SDPL), vocational students, job readiness

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Повышение готовности студентов к будущей профессиональной деятельности: отраслевая модель обучения навыкам самостоятельного проектирования (i-SDPL)

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Аннотация. *Введение.* Четвертая промышленная революция привела к серьезным изменениям как в экономике, так и в сфере подготовки кадров. Исследование представляет вариант модели обучения студентов самостоятельному проектированию для конкретной отрасли промышленности Индонезии. *Цель* исследования – разработка модели обучения, основанной на продукте и соответствующей потребностям отрасли, а также оценка ее эффективности в повышении готовности к работе студентов профессионально-технических училищ (VHS). *Методология, методы и методики.* В исследовании применялись тестовые методы с использованием таких инструментов, как интервью, анкетирование и практические тесты эффективности. *Результаты*. Разработанная модель i-SDPL объединяет опыт обучения в академической среде профессионально-технических училищ (VHS) с отраслевым компонентом, предназначенным для ознакомления студентов с профессиональной средой на предприятиях. Данная модель делает упор на самостоятельность студентов в разработке и реализации отраслевых проектов. Интеграция с промышленностью в рамках модели предоставляет студентам возможность получить доступ к новейшим технологиям и практическим знаниям, которые не всегда доступны в академической среде. Преимущества модели заключаются в активном участии студентов в работе предприятий, обучении на основе реальных продуктов и комплексном укреплении технической компетентности и мягких навыков по сравнению с традиционными методами. Эффективность модели i-SDPL оценивается на основе трех основных аспектов компетентности, каждый из которых имеет четкие показатели и критерии. Представленная модель обучения i-SDPL продемонстрировала свою эффективность в повышении компетентности в области отношения к делу, знаний и трудовых навыков у 136 студентов в ходе двух пробных внедрений. *Научная новизна.* Разработана оригинальная модель i-SDPL, позволяющая обеспечить интеграцию образовательных программ профессионального образования с потребностями конкретных отраслей промышленности. *Практическая значимость.* Широкое внедрение модели i-SDPL будет способствовать дальнейшему укреплению партнерских отношений между учреждениями профессионального образования и промышленностью. Результаты исследования не только актуальны для системы VHS в Индонезии, но и могут служить ориентиром для учреждений профессионального образования в других странах, сталкивающихся с аналогичными проблемами.

Ключевые слова: отраслевое обучение проектам самостоятельного проектирования (i-SDPL), студенты профессионально-технических училищ, готовность к работе

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Introduction

The Fourth Industrial Revolution, known as Industry 4.0, has brought about major changes in various sectors, including the world of work. In this era, the skills required are no longer limited to technical abilities, but also include soft skills such as critical thinking, creativity, and the ability to collaborate [1, 2]. Vocational high schools (VHSs) in Indonesia aim to produce a workforce that is competent and ready to face the world of work [3, 4, 5]. Therefore, adjustments are needed in the curriculum, learning methods, and competency standards to suit industry needs. However, there is still a gap between the world of education and the world of work, which causes VHS graduates to not be fully prepared to face challenges in the industry.

The Industry-Integrated Self-Design Project Learning (i-SDPL) model is emerging as a potential solution to address these challenges. The i-SDPL model is an extension of the existing SDPL model and emphasises the active involvement of students in designing and implementing relevant projects in learning. The main difference with the current SDPL model is that i-SDPL emphasises the active involvement of students in designing and implementing industry-relevant projects [6, 7]. In this model, students not only learn about theoretical concepts, but also apply their knowledge in real situations. Thus, students can develop technical skills and soft skills that are highly needed in the world of work [1, 8]. One of the advantages of i-SDPL is its ability to provide a more in-depth and contextualised learning experience for students. In their self-designed projects, students have to interact with various stakeholders, including teachers, industry professionals and peers [9, 10]. These interactions not only enrich their learning experience, but also help students build professional networks that can be useful in the future. In addition, students also learn to work in teams, resolve conflicts, and manage time effectively.

Integration with industry in SDPL provides opportunities for students to access the latest technology and practical knowledge that is not always available in an academic environment [11, 12]. Through collaboration with industry, students can keep up with the latest trends, understand market needs, and prepare themselves for upcoming challenges [13, 14]. This is especially important given the rapid changes in technology and the need for a flexible and adaptive workforce. Industry also benefits by being involved in the education process, such as identifying potential workforce candidates and contributing to the development of relevant curricula.

The perceptions of stakeholders, including students, teachers and industry, will be the main focus in assessing the success of this learning model. Students are expected to provide feedback on their learning experience, mastery of technical and soft skills, and the relevance of the project to industry needs. Teachers will provide perspectives on implementation challenges, benefits for improving the quality of learning, and the impact on teaching methods applied in the classroom. Meanwhile, the industry will assess students' work readiness, identify skills gaps, and provide recommendations to enhance the integration of SDPL with evolving industry demands.

In addition, this research will also assess how SDPL can be adapted and implemented in different contexts. Given the diversity of VHSs in Indonesia, it is important to understand the factors that may influence the successful implementation of this model, such as support from school Yes, I agree. Very good title. Thank you management, availability of resources, and linkages with industry. This study will explore various strategies that can be used to overcome these challenges, as well as evaluate how this model can be integrated with existing educational programmes.

With the growing need for a ready and competent workforce, it is important to evaluate and update existing learning approaches. Industry-Integrated SDPL (i-SDPL) offers an attractive model to improve the work readiness of vocational students [15]. The i-SDPL model emphasises student independence in designing and implementing industry-based projects, with direct integration in every stage of learning to improve work readiness. Its advantages lie in active industry involvement, real product-based learning, and holistic strengthening of technical competence and soft skills compared to conventional methods.

The performance of the i-SDPL model is evaluated based on three primary competency aspects, each with clear indicators and criteria: (a) Attitude. This is assessed through rigour, teamwork, diligence, discipline, as well as creativity and innovation, which reflect students' preparedness for a real work environment. (b) Knowledge. This is measured by the technical understanding and material knowledge required by the industry, ensuring that students master both the theory and its practical applications. (c) Skills. This encompasses mechanical and information technology skills, which are fundamental to industrial practice and the utilisation of modern technology [16, 17].

Overall, this research aims to provide a comprehensive insight into the development of an Industry-Integrated Self-Design Project Learning Model in VHS. By examining various aspects of this model, it is hoped that ways can be found to improve its effectiveness and provide maximum benefits for students. The results of this research are not only relevant for VHSs in Indonesia, but can also serve as a reference for vocational education institutions in other countries facing similar challenges.

Literature Review

Vocational High Schools (VHS) serve as educational institutions designed to prepare graduates for immediate entry into the workforce in their respective fields of expertise [18, 19]. VHS play a crucial role in meeting the labor demands of various industrial sectors. Consequently, the quality of VHS graduates directly impacts industrial productivity. According to S. Sukardi, W. Wildan, A. Subhani [15] and V. R. Palilingan, R. R. Oroh, M. S. S. Tumanduk et al. [20], well-prepared VHS graduates can seamlessly transition into the workforce, contributing effectively to their respective industries and enhancing overall productivity.

However, data from the Central Bureau of Statistics indicate that VHS graduates constitute the highest proportion of unemployed individuals, accounting for 9.6% of the total unemployment rate [21]. This high unemployment rate among VHS graduates can be attributed to several factors, with the primary issue being their level of job readiness [22]. Many graduates lack the necessary skills and practical experience demanded by employers, leading to a significant gap between education and employment. S. A. Rodzalan, N. N. Mohd Noor, N. H. Abdullah et al. [23] and W. Schulz, H. Solga, R. Pollak [24] stated that addressing this issue requires a comprehensive approach to improve the vocational training curriculum, incorporate industry-specific skills, and provide real-world experience to enhance the employability of VHS graduates.

In the study conducted by A. Prianto, W. Winardi, U. N. Qomariyah, it is established that the readiness to enter the workforce among graduates of VHS is formed through a comprehensive learning process that includes theoretical instruction, practical training, and industry exposure [25]. Vocational high schools have been progressively enhancing the quality of their education by integrating advanced educational methods and updating their curricula to meet the evolving demands of the job market [25, 26]. These efforts encompass a variety of initiatives, including the adoption of modern teaching techniques, the improvement of learning facilities, and the use of technology-enhanced learning tools. Despite these advancements, the issue of high unemployment rates among VHS graduates remains a significant challenge, requiring further strategic interventions.

A critical component of addressing this challenge is the establishment of robust partnerships between vocational high schools and industries [27]. D. W. Drewery, T. J. Pretti and D. Church noted that such collaborations are essential for aligning the educational outcomes of VHS students with the specific skills, knowledge, and attitudes required by employers [28]. By engaging directly with industries, vocational schools can ensure that their curricula are not only relevant but also forward-looking, preparing students for current and future job market demands [29, 30]. These partnerships facilitate the exchange of valuable insights and allow for the adaptation of teaching methodologies to better meet industry standards. As pointed out by D. Borah, K. Malik, S. Massini [31] and L. Underdahl, P. Akojie, M. Agustin Magabo et al. [32], industry involvement in the education process can provide students with practical experience and real-world exposure, further enhancing their readiness for employment.

I. García-Martínez, M. Montenegro-Rueda, E. Molina-Fernández et al. [33] and S. U. Nsanzumuhire, W. Groot [34] reported that a systematic approach is required to effectively implement these industry-school collaborations. This includes conducting comprehensive needs analyses to identify the specific competencies demanded by various sectors, developing detailed task descriptions that outline the expected job roles, and establishing clear competency standards that serve as benchmarks for student performance. Additionally, creating rigorous assessment procedures is crucial for evaluating whether students have acquired the necessary skills and knowledge. These assessments should be designed in consultation with industry experts to ensure their relevance and accuracy. Through these collaborative efforts, vocational high schools can produce graduates who are not only academically proficient but also possess the practical capabilities and professional attitudes required to thrive in the workforce [35, 36].

S. McGrath, S. Yamada [37], P. S. Rebia, Suharno, A. G. Tamrin et al. [38] and D. Rachmawati, S. Suharno, R. Roemintoyo [39] highlighted the pivotal factor contributing to the effective cultivation of work readiness among graduates of VHS, which resides in the proactive engagement of the industry in establishing competency benchmarks for VHS graduates, encompassing attitudes, knowledge, and skills. The main criterion for the implementation of VHS is the formation of competencies with standardisation in accordance with the needs of the world of work. L. Jie, T. Choicharoen, S. Juithong identified Self-Design Project Learning (SDPL) as a pedagogical methodology garnering increasing attention in vocational education [40]. SDPL stands out as a pedagogical model deemed suitable for adoption within vocational education settings. The fundamental aim of the SDPL framework is to align the caliber of vocational graduates with industry exigencies [41, 42]. SDPL is characterised by students acquiring proficiency in attitude, knowledge, and work skills through their engagement with products or projects. Much of the research conducted by F. N. Fauziah, K. Saddhono, E. Suryanto [43], N. B. Muliawan, I. A. Sulistijono [44], I. Tejawiani, I. Lastriyani, L. Lidiawati et al. [45] and M. A. Almulla [46] has focused on identifying the SDPL framework comprises seven distinct stages, namely: (a) Product/Project Planning; (b) Implementation; (c) Inquiry and Development; (d) Collaboration; (e) Evaluation; (f) Presentation; and (g) Reflection.

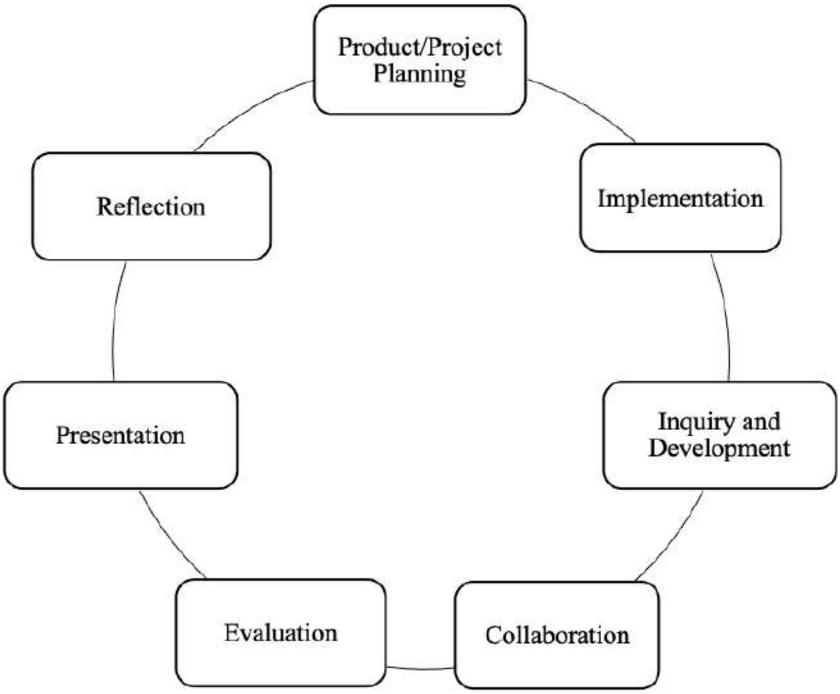

Fig. 1. Stages of the Self-Design Project Learning (SDPL) model

The i-SDPL (Industry-Integrated Self-Design Project Learning) model represents a refinement of traditional Project-Based Learning (PjBL), aimed at addressing the inherent limitations observed in the standard SDPL approach. Recent scholarly investigations, as documented by R. Zhang, J. Shi, J. Zhang [47], V. L. Hariyanto, R. Hidayah, G. N. I. Putra Pratama et al. [48], and P. Nilsook, P. Chatwattana, T. Seechaliao [49], have underscored deficiencies primarily pertaining to collaborative dynamics and the degree of industrial engagement within the educational milieu. These shortcomings have prompted a concerted effort to reconceptualise the SDPL framework, thereby fostering a more symbiotic relationship between academia and industry.

The integration of i-SDPL with industrial imperatives is multifaceted, encompassing several key facets. Firstly, it necessitates the alignment of educational objectives with the dynamic demands of contemporary industries. This alignment ensures that curricular content is not only relevant but also responsive to the evolving needs of the professional landscape. Secondly, the collaborative partnership between educators and industry stakeholders assumes paramount significance. By fostering close ties between these two spheres, i-SDPL endeavours to bridge the gap between theoretical knowledge and practical application, thereby imbuing students with a holistic understanding of their chosen vocation. Finally, the utilisation of industrial infrastructure serves to immerse students in an authentic work environment, thereby providing firsthand exposure to the challenges and nuances of their respective industries.

Ultimately, the overarching goal of integrating the i-SDPL model with industry is to enhance the vocational preparedness of students enrolled in Vocational High Schools (VHS) while simultaneously mitigating the incidence of post-graduation unemployment. Through a synergistic blend of academic rigor and real-world applicability, i-SDPL seeks to empower students with the requisite skills and competencies to thrive in an increasingly competitive job market. Moreover, by fostering a culture of collaboration and partnership between academia and industry, i-SDPL not only serves the immediate interests of students but also contributes to the broader socio-economic development of the communities it serves [50, 51, 52, 53].

Methodology, Materials and Methods

This study employed J. D. Richey's and R. C. Klein's research and development design, comprising three distinct stages of inquiry [54]. The stages of the research and development of the Industry-Integrated Self-Design Project Learning model are divided into 3 stages. These stages are needs analysis, internal validation and external validation. The needs analysis stage aims to explore information about the condition of learning in VHS, what aspects of competence are needed by the industry and VHS and what materials are currently needed by the industry and can be integrated with a product / project-based learning model. This stage involves 10 teachers and 12 industry practitioners to ensure that learning needs are accurately identified and aligned with industry requirements.

The Internal Validation stage aims to obtain feedback from experts to ensure that the learning model and Practical Performance Test instruments are suitable for application in the External Validation stage. This stage involves 2 vocational education experts and 2 industry practitioners who assess the feasibility of the developed models and instruments. Their input is used to refine and adjust the models before wider testing. The External Validation stage focuses on evaluating the effectiveness of the learning model in enhancing students' work readiness. This process involves a series of tests and trials, beginning with a pretest involving 32 students, followed by a limited test with 20 students, and culminating in a broader trial with 136 students. This phased approach allows for a thorough evaluation of the learning model, from small groups to larger cohorts, ensuring its effectiveness and reliability in an educational setting. The sequential progression of these research stages is illustrated in Figure 2.

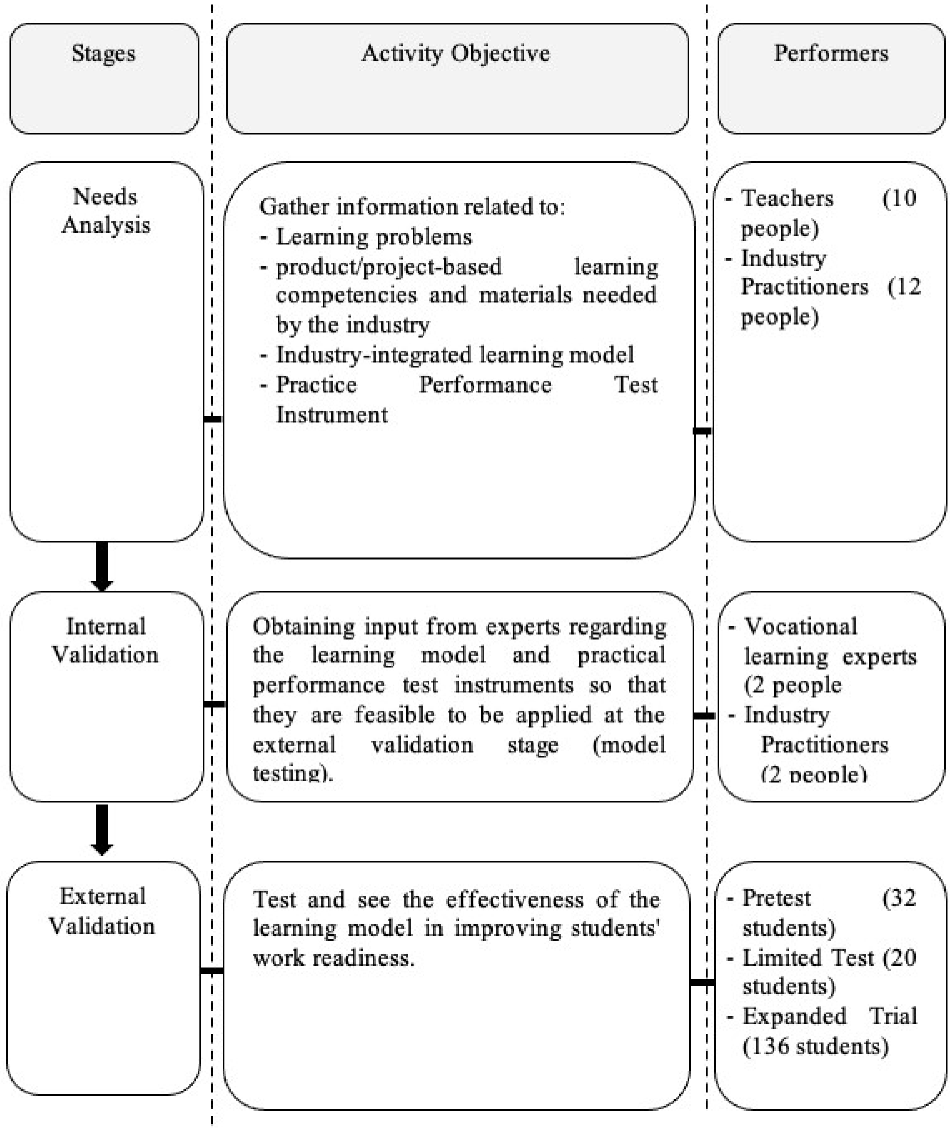

Fig. 2. Research and development procedures

The data collection methodologies employed in this study encompassed both test-based and non-test-based approaches. Non-test methodologies comprised interviews and questionnaires. The test-based methodology entailed a practical performance examination. Interviews were conducted through focused group discussions to glean insights into learning impediments, competencies, and the requisite product/project-oriented learning materials essential for industry integration.

Table 1

The internal validation instrument grids

No	Criteria	Assessment indicators
1	Relevance	The learning model is relevant to the learning objectives to be achieved
2	Necessity	The learning model is appropriate to the needs and characteristics of students.
3	Clarity	The instructions and steps in the learning model are clearly presented and easy to understand.
4	Readability	The language used in the learning model is easy to understand by students, teachers and industry practitioners.
5	Applicability	The learning model can be applied in the context of classroom learning
6	Effectiveness	The learning model is effective in improving aspects of student competence
7	Suitability to the curriculum	The learning model is in accordance with the applicable curriculum and is able to support the achievement of basic competencies that have been determined
8	Industry participation	The learning model encourages industry participation

To see the feasibility of the learning model and practical performance assessment instruments, validation and input from experts consisting of vocational education/learning experts and industry practitioners are required. Furthermore, the learning model and practical performance assessment instruments resulting from internal validation are applied to the external validation stage to determine the effectiveness of the learning model in improving students' work readiness. The internal validation instrument grids for experts and learning evaluation instruments can be seen in Table 1 and Table 2, respectively.

Table 2

Learning evaluation instruments

Competencies	Competency aspect
Attitude	Thoroughness
	Teamwork
	Hard work and discipline
	Creativity and innovation
Knowledge	Technical knowledge
	Material knowledge
Skills	Mechanical skills
	Information technology skills

The validity and reliability of the interview, questionnaire, and performance test instruments were assessed through rigorous content validity tests conducted by experts drawn from the realms of vocational learning and industry. Specifically, these experts held positions as car service advisors, ensuring a specialised understanding of the subject matter. Reliability testing, on the other hand, was executed utilising the Cronbach's alpha (α) test, a renowned measure known for its ability to ascertain internal consistency reliably. The outcomes consistently affirmed the instruments' reliability. The assessment instrument for the student practical performance test underwent meticulous development, spearheaded by VHS Automotive Engineering educators, automotive industry practitioners, and vocational learning authorities. Drawing upon the seminal research titled "Development of an Industry-Oriented Experiential Learning (EL+i) Model to Enhance Vocational High School Students' Job Readiness", as delineated in Table 3, the instrument was tailored to suit the exigencies of the study [55] .

Table 3

Categorisation of questionnaires and practical performance tests

Score	Category
3.01–4.00	Very effective
2.51–3.00	Effective
2.01–2.50	Less effective
0–2.00	Ineffective

Quantitative data analysis served as the cornerstone for evaluating both the model's feasibility questionnaire instrument and the practical performance assessment instrument, alongside the subsequent analysis of the practical performance test results. This analytical approach facilitated comprehensive categorisation and interpretation of the amassed data.

Research Results

Needs Analysis

The needs analysis stage aims to investigate learning challenges, required competencies, and the product or project-based learning materials necessary for industry integration. Data analysis was conducted through focus group discussions involving participants from vocational high school automotive engineering teachers and automotive industry practitioners. The findings from the needs analysis stage are presented in Table 4, Table 5, and Figure 3. The results indicate that the current industry demands product and project-based learning materials, specifically in the areas of electric vehicle modification, gas and electric welding, and oven painting.

Table 4

Learning problems

No.	Indicators	Vocational school teachers	Industry practitioners
1	Learning Planning	Teachers plan lessons in accordance with the instructions of related agencies; there is no role for industry.	VHSs do not collaborate with industry in lesson planning.
2	Learning Implementation	During this time, the implementation of learning is done by teachers themselves; the role of industry is absent.	VHSs passively collaborate and cooperate with industry in the implementation of learning.
3	Evaluation of Learning	VHS-based evaluation; no industry role.	VHS collaboration with industry is limited to graduation competency tests. Not implemented on every competency indicator required by VHS.

4	Graduate Quality	The quality of graduates is not certified by the industry.	The quality of graduates depends on the results of the VHS process, while industry contributes minimally.

The analysis reveals significant deficiencies in the collaboration between vocational high schools and industry in planning, implementation, evaluation, and graduate quality. The curriculum is developed and implemented unilaterally by vocational high schools without industry participation. Thus, industry involvement is lacking. Evaluation is primarily managed by vocational high schools, with industry participation limited to graduation competency tests, resulting in graduates lacking industry certification. To address these issues, it is recommended to establish partnerships between vocational high schools and industry to co-develop curricula that integrate current industry standards and practices.

Industry professionals should actively participate in teaching and provide practical training, while continuous evaluation involving industry practitioners should be implemented to ensure students meet the required competencies. In addition, certification processes developed in collaboration with industry should validate graduates' skills and knowledge, thereby improving their employability and ensuring vocational education is aligned with current industry standards.

Industry practitioners work together with vocational high schools to play an active role in the planning, implementation, evaluation, certification and sustainability of vocational high school graduates to form competency completeness that meets industry criteria.

Table 5

Competencies required by industry

Competencies	Competency aspect	Description
Attitude	Thoroughness	Ability to perform work with detail and accuracy.
	Teamwork	Ability to work with others in a team, collaborate and support each other to achieve common goals.
	Hard work and discipline	Ability to complete tasks in a timely manner and to a high standard of quality.
	Creativity and innovation	Ability to think beyond predictions, seek new solutions, or improve existing processes.
Knowledge	Technical knowledge	Ability about the principles, concepts, and specific details of a field of technology or science.
	Material knowledge	Understanding of the types of materials, their properties, processing methods and applications in technology, their properties, optimal use, and ways of processing and application in various contexts.
Skills	Mechanical skills	Skills in maintenance and repair of work equipment and field of work.
	Information technology skills	Skills in using software and related technology that supports work processes in industry.

The listed competencies are comprehensive and encompass essential areas for vocational students, particularly those specialising in electric vehicles. Attitude-related competencies prepare students to work effectively and innovate within teams.

Knowledge-based competencies provide the theoretical foundation necessary for understanding and applying technical concepts. Skill-related competencies ensure students can perform practical tasks and utilise modern technologies proficiently. Integrating these competencies into vocational education can significantly enhance students' readiness for the workforce, especially in technical and rapidly advancing fields such as electric vehicle technology.

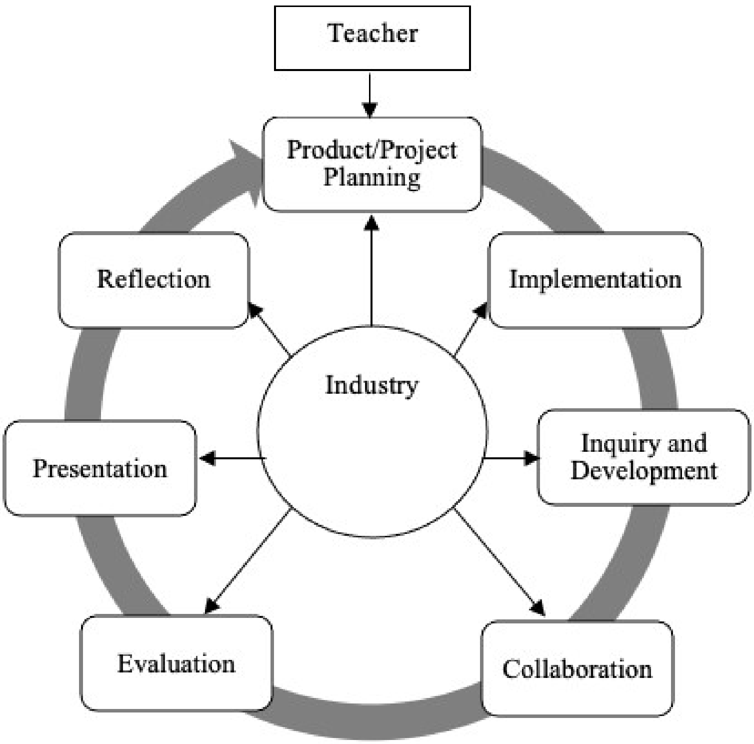

Fig. 3. i-SDPL model from needs analysis (conceptual)

Internal Validation

The internal validation stage aims to determine feasibility and seek input and suggestions from experts regarding the feasibility of practical performance assessment models and instruments, which will be applied at the external validation (trial) stage. Experts involved in the internal validation stage include: (a) vocational learning lecturers with over 15 years of academic experience, automotive competency certificates, and relevant work in automotive engineering, and (b) industry practitioners with over 10 years of experience as service advisors or workshop heads. The results of the internal validation indicate that the practical performance assessment instrument aligns with the measured competencies, rubric criteria, and scoring.

Regarding the stages of developing the i-SDPL learning model, some important points resulting from the internal validation stage are as follows: (a) i-SDPL emphasises collaboration between industry and educators at every stage of the model; (b) implementation of the model is feasible in both vocational schools and industry, taking into account the availability of learning facilities and infrastructure; (c) evaluation occurs in the industry with graduation standards aligned with industry needs. The revised i-SDPL learning model, incorporating feedback from the internal validation stage, is illustrated in Figure 4.

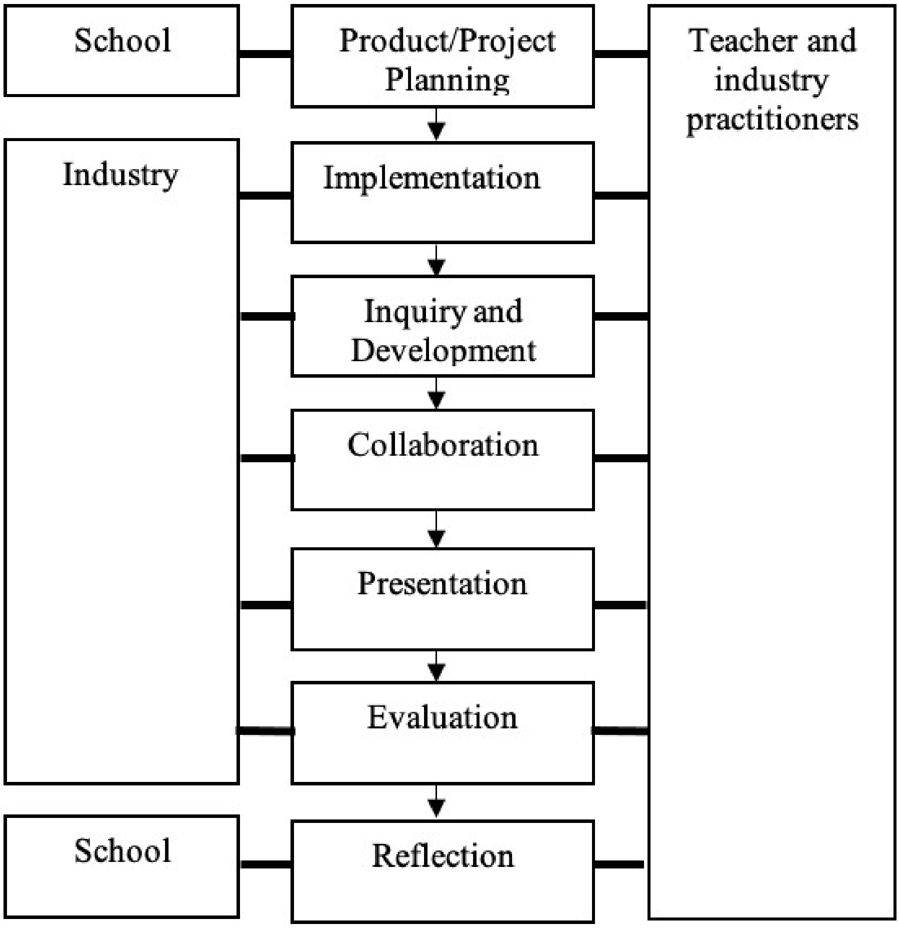

Fig. 4. Implementation of i-SDPL model

The i-SDPL model consists of stages that aim to shape the work readiness of the rest of the vocational school:

- The product/project planning contains activities aimed at establishing clear learning objectives, selecting appropriate projects/products, and scheduling their implementation.
- The implementation stage contains student activities in implementing learning in accordance with the learning plan. Teachers and industry practitioners ensure learning outcomes comply with industry standards. This phase is important for grounding theoretical knowledge in practical application.
- The investigation and development stage encourages students to complete learning tasks according to the knowledge and skills they have acquired.
- The collaboration stage is the stage where students interact directly with industry practitioners to gain experience, knowledge and skills according to the needs of the industrial world.
- The presentation stage contains activities to demonstrate the results of the problem solving process/tasks that have been studied. Here communication will be formed and produce input from other students, teachers and industry practitioners.
- The evaluation stage contains competency tests and feedback that are in line with industry standards.
- The final stage, reflection, allows teachers and industry practitioners to assess learning outcomes and develop further strategies for developing student competencies.

Table 4

Stages of Industry-Integrated Self-Design Project Learning (i-SDPL) model

Model stages	**Activities**	**Time**
Product/Project Planning	Industry practitioner and teacher together: - determine learning objectives; - determine the project or product that will be used for learning; - inform students about the work plan and schedule for learning implementation; and - divide the group.	Before learning
Implementation	Students start practising and working according to the projects planned by teachers and industry practitioners. Industry practitioners and teachers together provide guidance to students when needed.	According to industry standards
Inquiry and Development	– Students complete a project/product. – Student apply he attitudes, knowledge and skills gained from learning. – Industry practitioners and teachers together provide guidance to students when needed.	
Collaboration	Students interact with industry practitioners who are experienced in completing projects/products.	
Presentation	Students present the results of the project/product that is done.	10 minutes/ group

Evaluation	– Teachers and industry practitioners evaluate student progress on a regular basis. – Teachers or industry practitioners conduct competency tests. – Teachers and industry practitioners summarise and provide feedback to students.	As per industry standard
Reflection	Teachers and industry practitioners reflect on learning outcomes and plan steps for student competency development.	At the end of the lesson

External Validation

The external validation stage is divided into two: limited trial and extended trial stages. The purpose of external validation is to determine the effectiveness of the i-SDPL model in improving the work readiness of vocational students. External validation activities began with a pretest involving 32 students of VHS Muhammadiyah 2 Tempel. The subject matter tested was welding with a motorcycle chain cover project. The limited trial was conducted at VHS Muhammadiyah 1 Salam Magelang involving 20 students who studied welding with a toolbox project. Meanwhile, the extended trial was conducted at SMK Muhammadiyah 1 Salam and SMK Muhammadiyah Pakem, involving 136 students from the Automotive Engineering Department.

The analysis of the table indicates significant improvements across various categories attitude, knowledge, and skills from pretest to posttest. In the attitude category, there was a notable increase in creativity and innovation, with scores rising from 1.4 in the pretest to 3.6 in the posttest. Although some categories, such as conscientiousness and hard work and discipline, experienced a decline during the trials stage, both showed significant improvement in the posttest. The knowledge category also demonstrated a positive upward trend, with material knowledge increasing from 1.6 in the pretest to 3.6 in the posttest. Similarly, the skills category exhibited growth, with information technology skills improving from 1.4 in the pretest to 3.4 in the posttest.

Overall, these results suggest that the implemented programme or intervention was successful in enhancing participants' attitudes, knowledge, and skills, despite some fluctuations during the trials stage. This indicates that, despite initial challenges, participants were able to overcome and significantly improve their abilities through the learning process or intervention conducted. The results of the external validation stage can be seen in Figure 5.

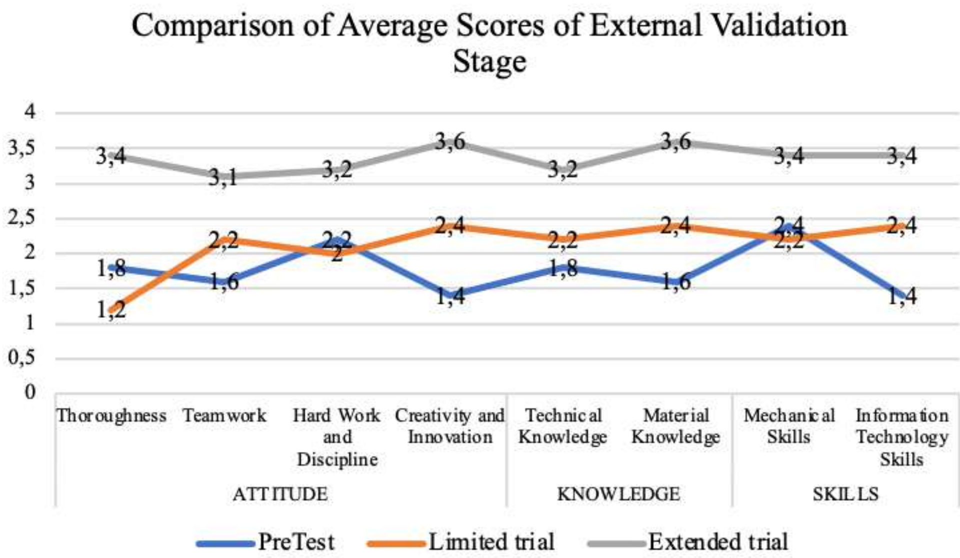

Fig. 5. Comparison of average scores of external validation stage

Results and Discussion

According to I. Tejawiani, I. Lastriyani, L. Lidiawati et al. [45], D. Guile, C. Spinuzzi [56], and L. Youyou, A. C. Kit [57], the Industry-Integrated Self-Design Project Learning (i-SDPL) model, derived from the Project Based Learning (PjBL) framework, emphasises the development of student competencies through direct engagement with industry-related projects and products. This model integrates theoretical and practical learning, fostering a holistic development of attitudes, knowledge, and skills. Key characteristics of the i-SDPL model include its collaborative approach, where educators and industry practitioners work together to guide students. The curriculum is aligned with industry standards, ensuring that the competencies students acquire are relevant and up-to-date with current industrial demands. Furthermore, the model includes rigorous stages of implementation and evaluation, conducted within industrial settings, which immerse students in real-world work environments. This not only bridges the gap between classroom learning and industry practice but also facilitates a smoother transition for students into the workforce.

According to C. Marnewick [58], H. Yudiono, S. Maulana, M. B. R. Wijaya et al. [59], and G. Pan, P.-S. Seow, V. Shankararaman et al. [60], in the i-SDPL learning model, the integration of project- and product-based learning with industry standards is essential in shaping students' competencies to meet industry needs. By working on real industrial projects, students gain practical experience and develop skills that can be directly applied in their future careers. This experiential learning approach not only improves technical proficiency, but also encourages critical thinking, problem-solving and collaboration skills. Exposure to the industrial climate plays an important role in preparing students for the professional environment by enhancing their understanding of industrial processes and work culture. This comprehensive exposure helps develop the character and work readiness of vocational high school (VHS) students, making them more adaptable and able to face the challenges of the modern industrial landscape. The i-SDPL model, therefore, represents a significant advancement in vocational education by ensuring that students are not only academically proficient but also industry-ready.

According to A. Saepudin [61], the i-SDPL learning model has been shown to be highly effective in improving work readiness across multiple dimensions, including attitude, knowledge and skills. The model significantly improves competence in the attitude of rigour. The statement is supported by H. B. Issa and A. Khataibeh [62], who state that project-based learning is a core component of the i-SDPL model that emphasises the final quality of the product. To achieve a high-quality product, students must pay careful attention to every detail and ensure that each step is done carefully, thus consistently developing attitudinal competence in the aspect of rigour. In addition, G. Aydın, O. Mutlu [63] and U. Usmeldi, R. Amini [64], stated that the i-SDPL learning model is an effective method to foster competence in teamwork. Student collaboration/cooperation in producing products/projects forms student competence in discussion and provides different knowledge.

According to Z. Zen, Reflianto, Syamsuar et al. [65], L. Zhang, Y. Ma [66] and T. Q. Tran, T. N. P. Tran [67], work competence and discipline refer to a person's ability to complete tasks on time with high quality standards. Through the application of the i-SDPL learning model by producing projects or products, students can create work that meets industry standards, which emphasise completeness, efficiency and perfection. By applying i-SDPL consistently, an optimal attitude of hard work and discipline will be formed. The next attitude competency is creativity and innovation. According to S. Hanif, A. F. C. Wijaya, N. Winarno [68], S. K. Ummah, A. Inam, R. D. Azmi [69], and A. Ahmad, B. Jabu [70], the application of i-SDPL will strengthen students' creativity and innovation attitudes. In the process of making products, students repeatedly receive input/direction from industry practitioners and teachers. The process encourages students to always innovate, looking for new ways to improve the quality of the products they produce, so that their creativity and innovation competencies are growing.

Motivational factors for all participants in the i-SDPL model include aspects from students, teachers, and industries involved in the learning process. The i-SDPL learning model stimulates students to understand and apply concepts and theories in product manufacturing. The question is supported by Syahril, Purwantono, R. E. Wulansari et al. [71] and M. H. Shin [72], that through the i-SDPL learning model, students more easily understand the relevance and importance of technical knowledge in practical applications. Not only that, this model also facilitates students to experience firsthand the process and challenges of completing a project or product.

This activity encourages students to develop technical skills from planning, implementation, to evaluation. In addition, the i-SDPL learning model improves students' material knowledge competence. This is supported by research conducted by N. Wijayati, W. Sumarni, S. Supanti [73], E. C. Miller, J. S. Krajcik [74], and M. Nasir, R. Fakhrunnisa, L. R. Nastiti [75], which showed that learning with the i-SDPL model can shape students' attitudes, knowledge, and work skills as a whole. Through this model, students not only understand the theory, but can also directly observe how these concepts are applied in making real projects or products. The integration of product-based learning models with industry allows students to gain practical experience in the use and processing of materials, so that they are better prepared to face challenges in the world of work.

For teachers, motivation comes from their role as facilitators who not only teach theory but also guide students in industry-based projects. This model allows teachers to update their insights through co-operation with industry as well as develop more innovative and effective learning methods. In addition, students' success in producing quality projects is a source of satisfaction for educators. For the industry, involvement in SDPL is an opportunity to get a more prepared and skilled workforce candidate according to the company's needs. By participating in the design and evaluation of projects, industries can ensure that graduates have competencies that meet their standards. In addition, this model also helps the industry to build close relationships with educational institutions, which can lead to wider cooperation in the future.

Mechanical skills competence refers to a person's practical ability to understand, maintain, repair and operate machine tools and components. The i-SDPL learning model is developed in accordance with industry needs and standardisation. Through the application of the model, students get the opportunity to apply the theory and concepts of machining in making projects or products. This question is in accordance with the results of research from W. Kurniawan, A. Budiono [76], H. Maksum, W. Purwanto [77], C. Y. Chao, Y.-C. Li, M.-S. Hour et al. [78], and S. Syahril, R. A. Nabawi, D. Safitri [79], who stated that by working according to industry standards, students can understand how the principles of mechanics apply in a real industrial context. S. Syahril, R. A. Nabawi, D. Safitri [79], J. Zhang, W. Wu, H. Li [80], H. Suswanto, A. Hamdan, R. R. Mariana et al. [81], M. D. C. Granado-Alcón, D. Gómez-Baya, E. Herrera-Gutiérrez et al. [82], stated that the project-based learning model integrated with industry can improve the competence of information technology skills. The statement is supported by V. J. Llorent, A. L. González-Gómez, D. P. Farrington et al. [83], and A. M. Al-Abdullatif, A. A. Gameil [84], that through the completion of industry-standard projects or products, students have the opportunity to interact with various tools, platforms and information technology commonly used in the industrial world. This learning activity equips students with practical and technical skills in operating, maintaining, and utilising various solutions using information technology.

The i-SDPL model has several limitations that can affect its effectiveness. One of the main challenges is the limited collaboration with industry, especially for schools that do not have easy access to relevant companies. This can be overcome by building a wider network of partnerships through internship programmes, curriculum cooperation and industry visits. In addition, limited resources and infrastructure in some schools are also an obstacle in implementing this model. Solutions that can be applied are the utilisation of simulation technology, cooperation with companies for access to industrial facilities, and procurement of equipment through educational grants.

On the other hand, students' level of independence in learning varies, which can affect the smooth running of their projects. To overcome this, initial training on project management, more intensive guidance from teachers and industry mentors, and periodic evaluations are needed to ensure students' progress. In addition, the evaluation of competency standards is also a challenge due to differences in industry standards that may affect the objectivity of the assessment. Therefore, the development of a standardised assessment rubric with the industry is a solution to ensure a more accurate evaluation and in accordance with the needs of the world of work. An explanation of these limitations and their solutions can be included in the Discussion section to provide insight into the challenges of i-SDPL implementation and strategies to improve its effectiveness.

Conclusion

The i-SDPL learning model is an innovative approach derived from the Project-Based Learning (PjBL) framework. The development of this model stems from a comprehensive needs analysis and feedback from industry experts and practitioners. The distinguishing feature of the i-SDPL model is the integration of industry involvement at every stage of the learning process, including preparation, implementation, and evaluation. Moreover, the i-SDPL model is executed in a blended format, combining learning experiences in vocational high schools (VHS) and industry settings. The industry component is designed to acquaint students with the professional work environment at an early stage.

The i-SDPL learning model has demonstrated its efficacy in enhancing competencies in attitude, knowledge, and work skills through two trial implementations. The implementation of the model is intended to benefit not only students but also teachers. For educators, the i-SDPL model serves as a mechanism to update and expand their knowledge in line with current industry advancements.

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Improving student readiness for future professional activities: the Industry-Integrated Self-Design Project Learning (i-SDPL) model

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Improving student readiness for future professional activities: the Industry-Integrated Self-Design Project Learning (i-SDPL) model

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Abstract. *Introduction.* The Fourth Industrial Revolution has brought about significant changes in both the economy and education. This study introduces a tailored self-design training model specific to Indonesia's industries for students. *Aim.* The present research *aims* to develop a learning model that is product-oriented and tailored to meet the needs of the industry. Additionally, it seeks to evaluate the model's effectiveness in enhancing the readiness of vocational high school (VHS) students. *Methodology and research methods*. The study employed various testing methods, including interviews, questionnaires, and practical performance assessments. *Results and scientific novelty*. The developed Industry-Integrated Self-Design Project Learning (i-SDPL) model integrates the learning experiences from VHSs with an industry component aimed at familiarising students with the professional environment of enterprises. This model emphasises student independence in the development and implementation of industry projects. The integration with industry within the model offers students access to the latest technologies and practical knowledge that may not always be available in an academic setting. The advantages of this model include active student participation in enterprise operations, training based on real products, and a comprehensive enhancement of both technical competencies and soft skills compared to traditional methods. The effectiveness of the i-SDPL model is evaluated based on three main competency aspects, each with clear indicators and criteria. The i-SDPL model has demonstrated its effectiveness in enhancing attitude, knowledge, and skills competency among 136 students across two trial implementations. *Scientific novelty.* An original i-SDPL model has been developed to ensure the integration of vocational education programmes with the specific needs of various industries. *Practical significance.* The widespread adoption of the i-SDPL model will further enhance partnerships between vocational education institutions and industry. The findings of this study are not only pertinent to the VHS system in Indonesia but can also serve as a valuable guide for vocational education institutions in other countries facing similar challenges.

Keywords: industry-integrated self-design project learning (i-SDPL), vocational students, job readiness

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Повышение готовности студентов к будущей профессиональной деятельности: отраслевая модель обучения навыкам самостоятельного проектирования (i-SDPL)

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Аннотация. *Введение.* Четвертая промышленная революция привела к серьезным изменениям как в экономике, так и в сфере подготовки кадров. Исследование представляет вариант модели обучения студентов самостоятельному проектированию для конкретной отрасли промышленности Индонезии. *Цель* исследования – разработка модели обучения, основанной на продукте и соответствующей потребностям отрасли, а также оценка ее эффективности в повышении готовности к работе студентов профессионально-технических училищ (VHS). *Методология, методы и методики.* В исследовании применялись тестовые методы с использованием таких инструментов, как интервью, анкетирование и практические тесты эффективности. *Результаты.* Разработанная модель i-SDPL объединяет опыт обучения в академической среде профессионально-технических училищ (VHS) с отраслевым компонентом, предназначенным для ознакомления студентов с профессиональной средой на предприятиях. Данная модель делает упор на самостоятельность студентов в разработке и реализации отраслевых проектов. Интеграция с промышленностью в рамках модели предоставляет студентам возможность получить доступ к новейшим технологиям и практическим знаниям, которые не всегда доступны в академической среде. Преимущества модели заключаются в активном участии студентов в работе предприятий, обучении на основе реальных продуктов и комплексном укреплении технической компетентности и мягких навыков по сравнению с традиционными методами. Эффективность модели i-SDPL оценивается на основе трех основных аспектов компетентности, каждый из которых имеет четкие показатели и критерии. Представленная модель обучения i-SDPL продемонстрировала свою эффективность в повышении компетентности в области отношения к делу, знаний и трудовых навыков у 136 студентов в ходе двух пробных внедрений. *Научная новизна.* Разработана оригинальная модель i-SDPL, позволяющая обеспечить интеграцию образовательных программ профессионального образования с потребностями конкретных отраслей промышленности. *Практическая значимость.* Широкое внедрение модели i-SDPL будет способствовать дальнейшему укреплению партнерских отношений между учреждениями профессионального образования и промышленностью. Результаты исследования не только актуальны для системы VHS в Индонезии, но и могут служить ориентиром для учреждений профессионального образования в других странах, сталкивающихся с аналогичными проблемами.

Ключевые слова: отраслевое обучение проектам самостоятельного проектирования (i-SDPL), студенты профессионально-технических училищ, готовность к работе

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Introduction

The Fourth Industrial Revolution, known as Industry 4.0, has brought about major changes in various sectors, including the world of work. In this era, the skills required are no longer limited to technical abilities, but also include soft skills such as critical thinking, creativity, and the ability to collaborate [1, 2]. Vocational high schools (VHSs) in Indonesia aim to produce a workforce that is competent and ready to face the world of work [3, 4, 5]. Therefore, adjustments are needed in the curriculum, learning methods, and competency standards to suit industry needs. However, there is still a gap between the world of education and the world of work, which causes VHS graduates to not be fully prepared to face challenges in the industry.

The Industry-Integrated Self-Design Project Learning (i-SDPL) model is emerging as a potential solution to address these challenges. The i-SDPL model is an extension of the existing SDPL model and emphasises the active involvement of students in designing and implementing relevant projects in learning. The main difference with the current SDPL model is that i-SDPL emphasises the active involvement of students in designing and implementing industry-relevant projects [6, 7]. In this model, students not only learn about theoretical concepts, but also apply their knowledge in real situations. Thus, students can develop technical skills and soft skills that are highly needed in the world of work [1, 8]. One of the advantages of i-SDPL is its ability to provide a more in-depth and contextualised learning experience for students. In their self-designed projects, students have to interact with various stakeholders, including teachers, industry professionals and peers [9, 10]. These interactions not only enrich their learning experience, but also help students build professional networks that can be useful in the future. In addition, students also learn to work in teams, resolve conflicts, and manage time effectively.

Integration with industry in SDPL provides opportunities for students to access the latest technology and practical knowledge that is not always available in an academic environment [11, 12]. Through collaboration with industry, students can keep up with the latest trends, understand market needs, and prepare themselves for upcoming challenges [13, 14]. This is especially important given the rapid changes in technology and the need for a flexible and adaptive workforce. Industry also benefits by being involved in the education process, such as identifying potential workforce candidates and contributing to the development of relevant curricula.

The perceptions of stakeholders, including students, teachers and industry, will be the main focus in assessing the success of this learning model. Students are expected to provide feedback on their learning experience, mastery of technical and soft skills, and the relevance of the project to industry needs. Teachers will provide perspectives on implementation challenges, benefits for improving the quality of learning, and the impact on teaching methods applied in the classroom. Meanwhile, the industry will assess students' work readiness, identify skills gaps, and provide recommendations to enhance the integration of SDPL with evolving industry demands.

In addition, this research will also assess how SDPL can be adapted and implemented in different contexts. Given the diversity of VHSs in Indonesia, it is important to understand the factors that may influence the successful implementation of this model, such as support from school Yes, I agree. Very good title. Thank you management, availability of resources, and linkages with industry. This study will explore various strategies that can be used to overcome these challenges, as well as evaluate how this model can be integrated with existing educational programmes.

With the growing need for a ready and competent workforce, it is important to evaluate and update existing learning approaches. Industry-Integrated SDPL (i-SDPL) offers an attractive model to improve the work readiness of vocational students [15]. The i-SDPL model emphasises student independence in designing and implementing industry-based projects, with direct integration in every stage of learning to improve work readiness. Its advantages lie in active industry involvement, real product-based learning, and holistic strengthening of technical competence and soft skills compared to conventional methods.

The performance of the i-SDPL model is evaluated based on three primary competency aspects, each with clear indicators and criteria: (a) Attitude. This is assessed through rigour, teamwork, diligence, discipline, as well as creativity and innovation, which reflect students' preparedness for a real work environment. (b) Knowledge. This is measured by the technical understanding and material knowledge required by the industry, ensuring that students master both the theory and its practical applications. (c) Skills. This encompasses mechanical and information technology skills, which are fundamental to industrial practice and the utilisation of modern technology [16, 17].

Overall, this research aims to provide a comprehensive insight into the development of an Industry-Integrated Self-Design Project Learning Model in VHS. By examining various aspects of this model, it is hoped that ways can be found to improve its effectiveness and provide maximum benefits for students. The results of this research are not only relevant for VHSs in Indonesia, but can also serve as a reference for vocational education institutions in other countries facing similar challenges.

Literature Review

Vocational High Schools (VHS) serve as educational institutions designed to prepare graduates for immediate entry into the workforce in their respective fields of expertise [18, 19]. VHS play a crucial role in meeting the labor demands of various industrial sectors. Consequently, the quality of VHS graduates directly impacts industrial productivity. According to S. Sukardi, W. Wildan, A. Subhani [15] and V. R. Palilingan, R. R. Oroh, M. S. S. Tumanduk et al. [20], well-prepared VHS graduates can seamlessly transition into the workforce, contributing effectively to their respective industries and enhancing overall productivity.

However, data from the Central Bureau of Statistics indicate that VHS graduates constitute the highest proportion of unemployed individuals, accounting for 9.6% of the total unemployment rate [21]. This high unemployment rate among VHS graduates can be attributed to several factors, with the primary issue being their level of job readiness [22]. Many graduates lack the necessary skills and practical experience demanded by employers, leading to a significant gap between education and employment. S. A. Rodzalan, N. N. Mohd Noor, N. H. Abdullah et al. [23] and W. Schulz, H. Solga, R. Pollak [24] stated that addressing this issue requires a comprehensive approach to improve the vocational training curriculum, incorporate industry-specific skills, and provide real-world experience to enhance the employability of VHS graduates.

In the study conducted by A. Prianto, W. Winardi, U. N. Qomariyah, it is established that the readiness to enter the workforce among graduates of VHS is formed through a comprehensive learning process that includes theoretical instruction, practical training, and industry exposure [25]. Vocational high schools have been progressively enhancing the quality of their education by integrating advanced educational methods and updating their curricula to meet the evolving demands of the job market [25, 26]. These efforts encompass a variety of initiatives, including the adoption of modern teaching techniques, the improvement of learning facilities, and the use of technology-enhanced learning tools. Despite these advancements, the issue of high unemployment rates among VHS graduates remains a significant challenge, requiring further strategic interventions.

A critical component of addressing this challenge is the establishment of robust partnerships between vocational high schools and industries [27]. D. W. Drewery, T. J. Pretti and D. Church noted that such collaborations are essential for aligning the educational outcomes of VHS students with the specific skills, knowledge, and attitudes required by employers [28]. By engaging directly with industries, vocational schools can ensure that their curricula are not only relevant but also forward-looking, preparing students for current and future job market demands [29, 30]. These partnerships facilitate the exchange of valuable insights and allow for the adaptation of teaching methodologies to better meet industry standards. As pointed out by D. Borah, K. Malik, S. Massini [31] and L. Underdahl, P. Akojie, M. Agustin Magabo et al. [32], industry involvement in the education process can provide students with practical experience and real-world exposure, further enhancing their readiness for employment.

I. García-Martínez, M. Montenegro-Rueda, E. Molina-Fernández et al. [33] and S. U. Nsanzumuhire, W. Groot [34] reported that a systematic approach is required to effectively implement these industry-school collaborations. This includes conducting comprehensive needs analyses to identify the specific competencies demanded by various sectors, developing detailed task descriptions that outline the expected job roles, and establishing clear competency standards that serve as benchmarks for student performance. Additionally, creating rigorous assessment procedures is crucial for evaluating whether students have acquired the necessary skills and knowledge. These assessments should be designed in consultation with industry experts to ensure their relevance and accuracy. Through these collaborative efforts, vocational high schools can produce graduates who are not only academically proficient but also possess the practical capabilities and professional attitudes required to thrive in the workforce [35, 36].

S. McGrath, S. Yamada [37], P. S. Rebia, Suharno, A. G. Tamrin et al. [38] and D. Rachmawati, S. Suharno, R. Roemintoyo [39] highlighted the pivotal factor contributing to the effective cultivation of work readiness among graduates of VHS, which resides in the proactive engagement of the industry in establishing competency benchmarks for VHS graduates, encompassing attitudes, knowledge, and skills. The main criterion for the implementation of VHS is the formation of competencies with standardisation in accordance with the needs of the world of work. L. Jie, T. Choicharoen, S. Juithong identified Self-Design Project Learning (SDPL) as a pedagogical methodology garnering increasing attention in vocational education [40]. SDPL stands out as a pedagogical model deemed suitable for adoption within vocational education settings. The fundamental aim of the SDPL framework is to align the caliber of vocational graduates with industry exigencies [41, 42]. SDPL is characterised by students acquiring proficiency in attitude, knowledge, and work skills through their engagement with products or projects. Much of the research conducted by F. N. Fauziah, K. Saddhono, E. Suryanto [43], N. B. Muliawan, I. A. Sulistijono [44], I. Tejawiani, I. Lastriyani, L. Lidiawati et al. [45] and M. A. Almulla [46] has focused on identifying the SDPL framework comprises seven distinct stages, namely: (a) Product/Project Planning; (b) Implementation; (c) Inquiry and Development; (d) Collaboration; (e) Evaluation; (f) Presentation; and (g) Reflection.

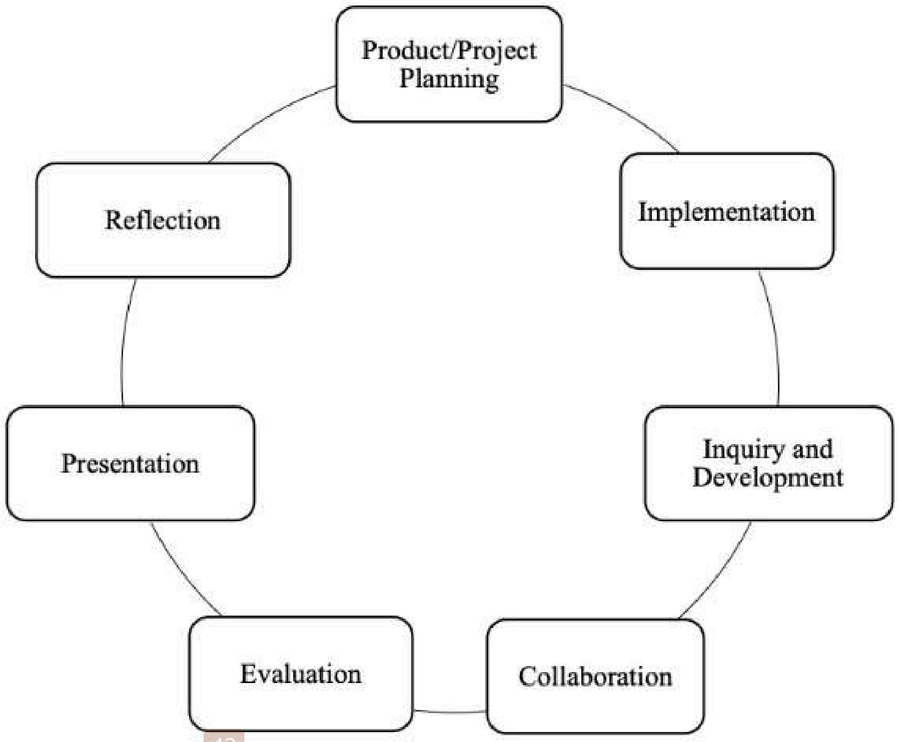

Fig. 1. Stages of the Self-Design Project Learning (SDPL) model

The i-SDPL (Industry-Integrated Self-Design Project Learning) model represents a refinement of traditional Project-Based Learning (PjBL), aimed at addressing the inherent limitations observed in the standard SDPL approach. Recent scholarly investigations, as documented by R. Zhang, J. Shi, J. Zhang [47], V. L. Hariyanto, R. Hidayah, G. N. I. Putra Pratama et al. [48], and P. Nilsook, P. Chatwattana, T. Seechaliao [49], have underscored deficiencies primarily pertaining to collaborative dynamics and the degree of industrial engagement within the educational milieu. These shortcomings have prompted a concerted effort to reconceptualise the SDPL framework, thereby fostering a more symbiotic relationship between academia and industry.

The integration of i-SDPL with industrial imperatives is multifaceted, encompassing several key facets. Firstly, it necessitates the alignment of educational objectives with the dynamic demands of contemporary industries. This alignment ensures that curricular content is not only relevant but also responsive to the evolving needs of the professional landscape. Secondly, the collaborative partnership between educators and industry stakeholders assumes paramount significance. By fostering close ties between these two spheres, i-SDPL endeavours to bridge the gap between theoretical knowledge and practical application, thereby imbuing students with a holistic understanding of their chosen vocation. Finally, the utilisation of industrial infrastructure serves to immerse students in an authentic work environment, thereby providing firsthand exposure to the challenges and nuances of their respective industries.

Ultimately, the overarching goal of integrating the i-SDPL model with industry is to enhance the vocational preparedness of students enrolled in Vocational High Schools (VHS) while simultaneously mitigating the incidence of post-graduation unemployment. Through a synergistic blend of academic rigor and real-world applicability, i-SDPL seeks to empower students with the requisite skills and competencies to thrive in an increasingly competitive job market. Moreover, by fostering a culture of collaboration and partnership between academia and industry, i-SDPL not only serves the immediate interests of students but also contributes to the broader socio-economic development of the communities it serves [50, 51, 52, 53].

Methodology, Materials and Methods

This study employed J. D. Richey's and R. C. Klein's research and development design, comprising three distinct stages of inquiry [54]. The stages of the research and development of the Industry-Integrated Self-Design Project Learning model are divided into 3 stages. These stages are needs analysis, internal validation and external validation. The needs analysis stage aims to explore information about the condition of learning in VHS, what aspects of competence are needed by the industry and VHS and what materials are currently needed by the industry and can be integrated with a product / project-based learning model. This stage involves 10 teachers and 12 industry practitioners to ensure that learning needs are accurately identified and aligned with industry requirements.

The Internal Validation stage aims to obtain feedback from experts to ensure that the learning model and Practical Performance Test instruments are suitable for application in the External Validation stage. This stage involves 2 vocational education experts and 2 industry practitioners who assess the feasibility of the developed models and instruments. Their input is used to refine and adjust the models before wider testing. The External Validation stage focuses on evaluating the effectiveness of the learning model in enhancing students' work readiness. This process involves a series of tests and trials, beginning with a pretest involving 32 students, followed by a limited test with 20 students, and culminating in a broader trial with 136 students. This phased approach allows for a thorough evaluation of the learning model, from small groups to larger cohorts, ensuring its effectiveness and reliability in an educational setting. The sequential progression of these research stages is illustrated in Figure 2.

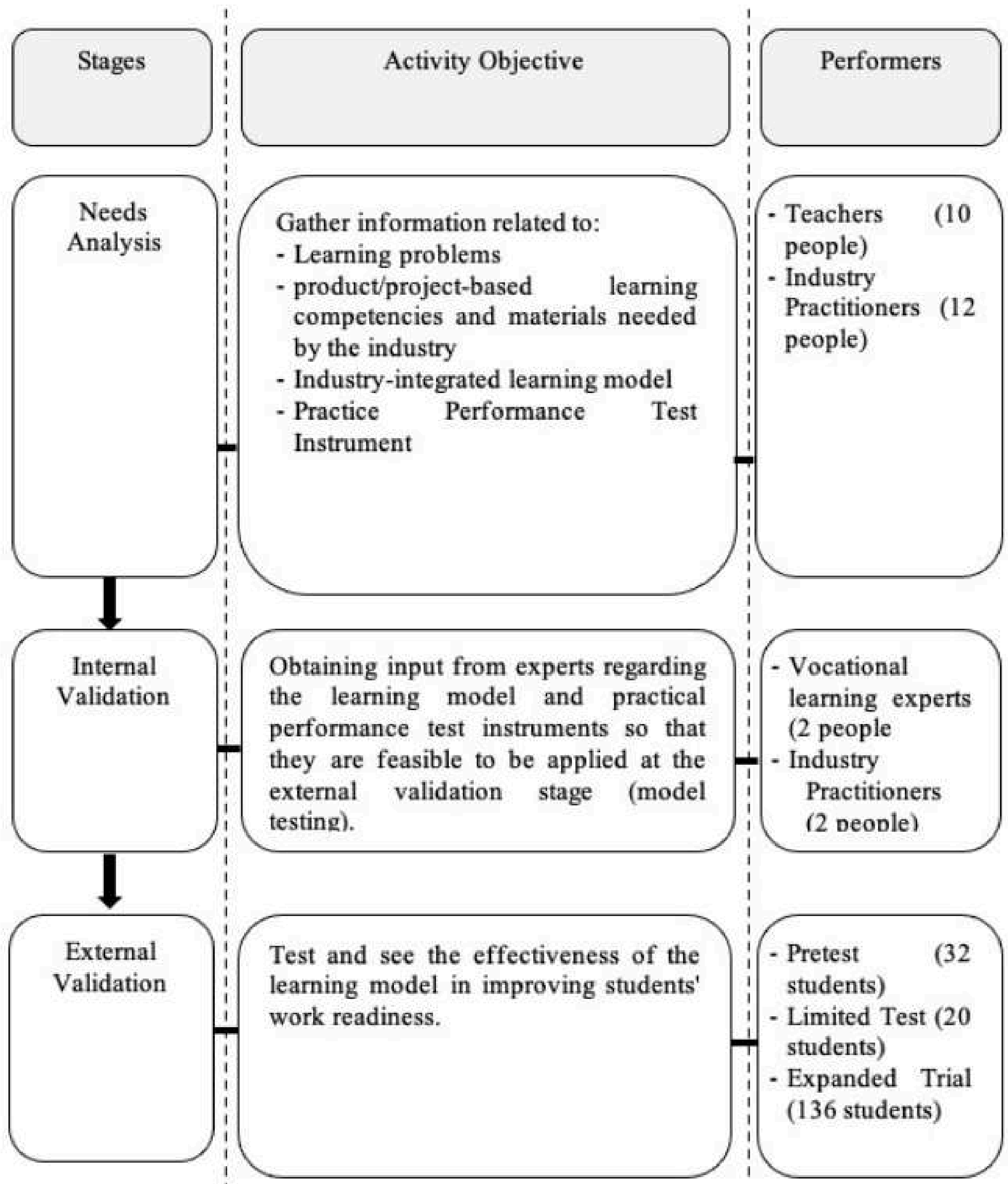

Fig. 2. Research and development procedures

The data collection methodologies employed in this study encompassed both test-based and non-test-based approaches. Non-test methodologies comprised interviews and questionnaires. The test-based methodology entailed a practical performance examination. Interviews were conducted through focused group discussions to glean insights into learning impediments, competencies, and the requisite product/project-oriented learning materials essential for industry integration.

Table 1

The internal validation instrument grids

No	Criteria	Assessment indicators
1	Relevance	The learning model is relevant to the learning objectives to be achieved
2	Necessity	The learning model is appropriate to the needs and characteristics of students.
3	Clarity	The instructions and steps in the learning model are clearly presented and easy to understand.
4	Readability	The language used in the learning model is easy to understand by students, teachers and industry practitioners.
5	Applicability	The learning model can be applied in the context of classroom learning
6	Effectiveness	The learning model is effective in improving aspects of student competence
7	Suitability to the curriculum	The learning model is in accordance with the applicable curriculum and is able to support the achievement of basic competencies that have been determined
8	Industry participation	The learning model encourages industry participation

To see the feasibility of the learning model and practical performance assessment instruments, validation and input from experts consisting of vocational education/learning experts and industry practitioners are required. Furthermore, the learning model and practical performance assessment instruments resulting from internal validation are applied to the external validation stage to determine the effectiveness of the learning model in improving students' work readiness. The internal validation instrument grids for experts and learning evaluation instruments can be seen in Table 1 and Table 2, respectively.

Table 2

Learning evaluation instruments

Competencies	Competency aspect
Attitude	Thoroughness
	Teamwork
	Hard work and discipline
	Creativity and innovation
Knowledge	Technical knowledge
	Material knowledge
Skills	Mechanical skills
	Information technology skills

The validity and reliability of the interview, questionnaire, and performance test instruments were assessed through rigorous content validity tests conducted by experts drawn from the realms of vocational learning and industry. Specifically, these experts held positions as car service advisors, ensuring a specialised understanding of the subject matter. Reliability testing, on the other hand, was executed utilising the Cronbach's alpha (α) test, a renowned measure known for its ability to ascertain internal consistency reliably. The outcomes consistently affirmed the instruments' reliability. The assessment instrument for the student practical performance test underwent meticulous development, spearheaded by VHS Automotive Engineering educators, automotive industry practitioners, and vocational learning authorities. Drawing upon the seminal research titled "Development of an Industry-Oriented Experiential Learning (EL+i) Model to Enhance Vocational High School Students' Job Readiness", as delineated in Table 3, the instrument was tailored to suit the exigencies of the study [55] .

Table 3

Categorisation of questionnaires and practical performance tests

Score	Category
3.01–4.00	Very effective
2.51–3.00	Effective
2.01–2.50	Less effective
0–2.00	Ineffective

Quantitative data analysis served as the cornerstone for evaluating both the model's feasibility questionnaire instrument and the practical performance assessment instrument, alongside the subsequent analysis of the practical performance test results. This analytical approach facilitated comprehensive categorisation and interpretation of the amassed data.

Research Results

Needs Analysis

The needs analysis stage aims to investigate learning challenges, required competencies, and the product or project-based learning materials necessary for industry integration. Data analysis was conducted through focus group discussions involving participants from vocational high school automotive engineering teachers and automotive industry practitioners. The findings from the needs analysis stage are presented in Table 4, Table 5, and Figure 3. The results indicate that the current industry demands product and project-based learning materials, specifically in the areas of electric vehicle modification, gas and electric welding, and oven painting.

Table 4

Learning problems

No.	Indicators	Vocational school teachers	Industry practitioners
1	Learning Planning	Teachers plan lessons in accordance with the instructions of related agencies; there is no role for industry.	VHSs do not collaborate with industry in lesson planning.
2	Learning Implementation	During this time, the implementation of learning is done by teachers themselves; the role of industry is absent.	VHSs passively collaborate and cooperate with industry in the implementation of learning.
3	Evaluation of Learning	VHS-based evaluation; no industry role.	VHS collaboration with industry is limited to graduation competency tests. Not implemented on every competency indicator required by VHS.

4	Graduate Quality	The quality of graduates is not certified by the industry.	The quality of graduates depends on the results of the VHS process, while industry contributes minimally.

The analysis reveals significant deficiencies in the collaboration between vocational high schools and industry in planning, implementation, evaluation, and graduate quality. The curriculum is developed and implemented unilaterally by vocational high schools without industry participation. Thus, industry involvement is lacking. Evaluation is primarily managed by vocational high schools, with industry participation limited to graduation competency tests, resulting in graduates lacking industry certification. To address these issues, it is recommended to establish partnerships between vocational high schools and industry to co-develop curricula that integrate current industry standards and practices.

Industry professionals should actively participate in teaching and provide practical training, while continuous evaluation involving industry practitioners should be implemented to ensure students meet the required competencies. In addition, certification processes developed in collaboration with industry should validate graduates' skills and knowledge, thereby improving their employability and ensuring vocational education is aligned with current industry standards.

Industry practitioners work together with vocational high schools to play an active role in the planning, implementation, evaluation, certification and sustainability of vocational high school graduates to form competency completeness that meets industry criteria.

Table 5

Competencies required by industry

Competencies	Competency aspect	Description
Attitude	Thoroughness	Ability to perform work with detail and accuracy.
	Teamwork	Ability to work with others in a team, collaborate and support each other to achieve common goals.
	Hard work and discipline	Ability to complete tasks in a timely manner and to a high standard of quality.
	Creativity and innovation	Ability to think beyond predictions, seek new solutions, or improve existing processes.
Knowledge	Technical knowledge	Ability about the principles, concepts, and specific details of a field of technology or science.
	Material knowledge	Understanding of the types of materials, their properties, processing methods and applications in technology, their properties, optimal use, and ways of processing and application in various contexts.
Skills	Mechanical skills	Skills in maintenance and repair of work equipment and field of work.
	Information technology skills	Skills in using software and related technology that supports work processes in industry.

The listed competencies are comprehensive and encompass essential areas for vocational students, particularly those specialising in electric vehicles. Attitude-related competencies prepare students to work effectively and innovate within teams.

Knowledge-based competencies provide the theoretical foundation necessary for understanding and applying technical concepts. Skill-related competencies ensure students can perform practical tasks and utilise modern technologies proficiently. Integrating these competencies into vocational education can significantly enhance students' readiness for the workforce, especially in technical and rapidly advancing fields such as electric vehicle technology.

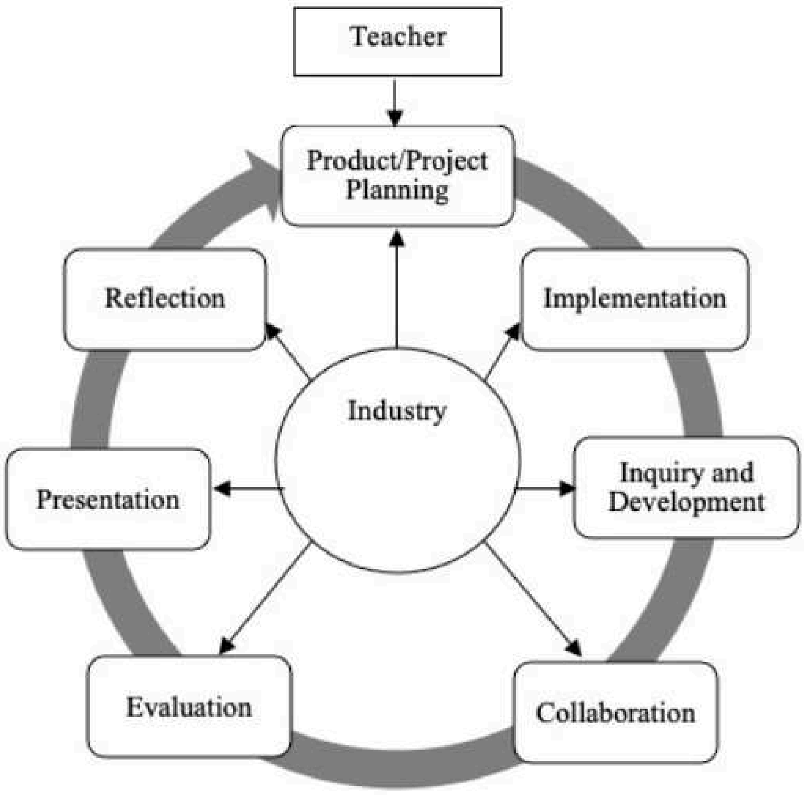

Fig. 3. i-SDPL model from needs analysis (conceptual)

Internal Validation

The internal validation stage aims to determine feasibility and seek input and suggestions from experts regarding the feasibility of practical performance assessment models and instruments, which will be applied at the external validation (trial) stage. Experts involved in the internal validation stage include: (a) vocational learning lecturers with over 15 years of academic experience, automotive competency certificates, and relevant work in automotive engineering, and (b) industry practitioners with over 10 years of experience as service advisors or workshop heads. The results of the internal validation indicate that the practical performance assessment instrument aligns with the measured competencies, rubric criteria, and scoring.

Regarding the stages of developing the i-SDPL learning model, some important points resulting from the internal validation stage are as follows: (a) i-SDPL emphasises collaboration between industry and educators at every stage of the model; (b) implementation of the model is feasible in both vocational schools and industry, taking into account the availability of learning facilities and infrastructure; (c) evaluation occurs in the industry with graduation standards aligned with industry needs. The revised i-SDPL learning model, incorporating feedback from the internal validation stage, is illustrated in Figure 4.

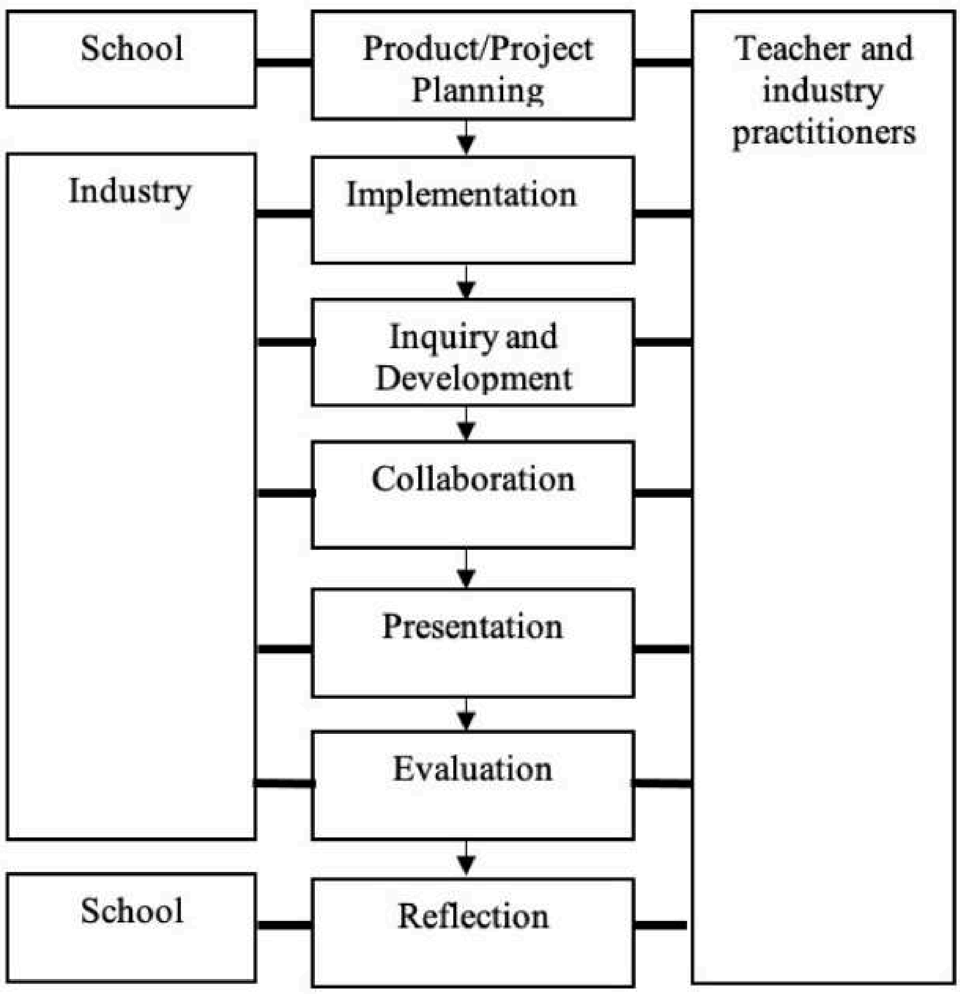

Fig. 4. Implementation of i-SDPL model

The i-SDPL model consists of stages that aim to shape the work readiness of the rest of the vocational school:

- The product/project planning contains activities aimed at establishing clear learning objectives, selecting appropriate projects/products, and scheduling their implementation.
- The implementation stage contains student activities in implementing learning in accordance with the learning plan. Teachers and industry practitioners ensure learning outcomes comply with industry standards. This phase is important for grounding theoretical knowledge in practical application.
- The investigation and development stage encourages students to complete learning tasks according to the knowledge and skills they have acquired.
- The collaboration stage is the stage where students interact directly with industry practitioners to gain experience, knowledge and skills according to the needs of the industrial world.
- The presentation stage contains activities to demonstrate the results of the problem solving process/tasks that have been studied. Here communication will be formed and produce input from other students, teachers and industry practitioners.
- The evaluation stage contains competency tests and feedback that are in line with industry standards.
- The final stage, reflection, allows teachers and industry practitioners to assess learning outcomes and develop further strategies for developing student competencies.

Table 4

Stages of Industry-Integrated Self-Design Project Learning (i-SDPL) model

Model stages	Activities	Time
Product/Project Planning	Industry practitioner and teacher together: - determine learning objectives; - determine the project or product that will be used for learning; - inform students about the work plan and schedule for learning implementation; and - divide the group.	Before learning
Implementation	Students start practising and working according to the projects planned by teachers and industry practitioners. Industry practitioners and teachers together provide guidance to students when needed.	According to industry standards
Inquiry and Development	– Students complete a project/product. – Student apply he attitudes, knowledge and skills gained from learning. – Industry practitioners and teachers together provide guidance to students when needed.	
Collaboration	Students interact with industry practitioners who are experienced in completing projects/products.	
Presentation	Students present the results of the project/product that is done.	10 minutes/ group

Evaluation	– Teachers and industry practitioners evaluate student progress on a regular basis. – Teachers or industry practitioners conduct competency tests. – Teachers and industry practitioners summarise and provide feedback to students.	As per industry standard
Reflection	Teachers and industry practitioners reflect on learning outcomes and plan steps for student competency development.	At the end of the lesson

External Validation

The external validation stage is divided into two: limited trial and extended trial stages. The purpose of external validation is to determine the effectiveness of the i-SDPL model in improving the work readiness of vocational students. External validation activities began with a pretest involving 32 students of VHS Muhammadiyah 2 Tempel. The subject matter tested was welding with a motorcycle chain cover project. The limited trial was conducted at VHS Muhammadiyah 1 Salam Magelang involving 20 students who studied welding with a toolbox project. Meanwhile, the extended trial was conducted at SMK Muhammadiyah 1 Salam and SMK Muhammadiyah Pakem, involving 136 students from the Automotive Engineering Department.

The analysis of the table indicates significant improvements across various categories attitude, knowledge, and skills from pretest to posttest. In the attitude category, there was a notable increase in creativity and innovation, with scores rising from 1.4 in the pretest to 3.6 in the posttest. Although some categories, such as conscientiousness and hard work and discipline, experienced a decline during the trials stage, both showed significant improvement in the posttest. The knowledge category also demonstrated a positive upward trend, with material knowledge increasing from 1.6 in the pretest to 3.6 in the posttest. Similarly, the skills category exhibited growth, with information technology skills improving from 1.4 in the pretest to 3.4 in the posttest.

Overall, these results suggest that the implemented programme or intervention was successful in enhancing participants' attitudes, knowledge, and skills, despite some fluctuations during the trials stage. This indicates that, despite initial challenges, participants were able to overcome and significantly improve their abilities through the learning process or intervention conducted. The results of the external validation stage can be seen in Figure 5.

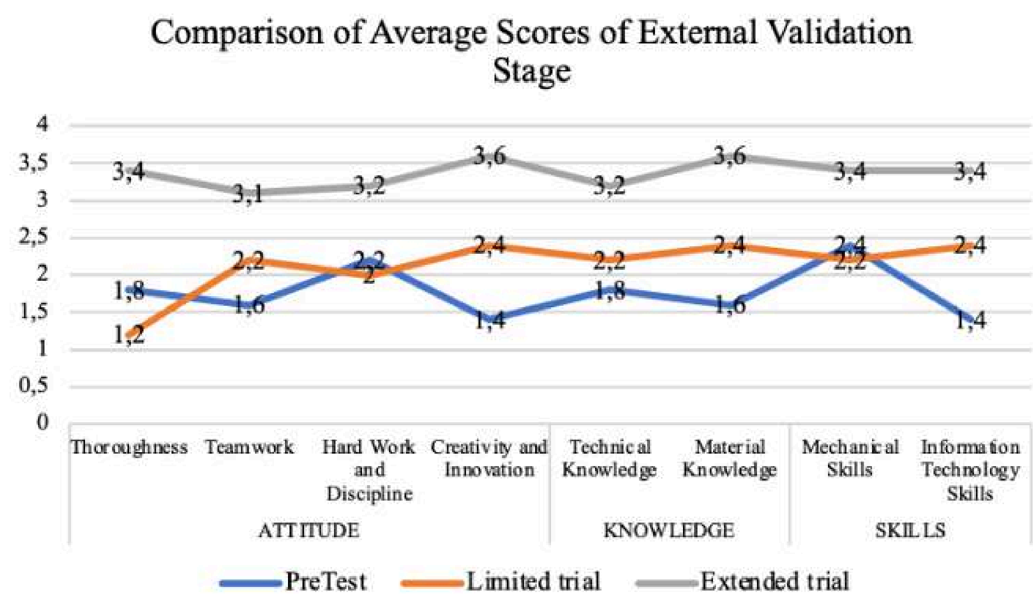

Fig. 5. Comparison of average scores of external validation stage

Results and Discussion

According to I. Tejawiani, I. Lastriyani, L. Lidiawati et al. [45], D. Guile, C. Spinuzzi [56], and L. Youyou, A. C. Kit [57], the Industry-Integrated Self-Design Project Learning (i-SDPL) model, derived from the Project Based Learning (PjBL) framework, emphasises the development of student competencies through direct engagement with industry-related projects and products. This model integrates theoretical and practical learning, fostering a holistic development of attitudes, knowledge, and skills. Key characteristics of the i-SDPL model include its collaborative approach, where educators and industry practitioners work together to guide students. The curriculum is aligned with industry standards, ensuring that the competencies students acquire are relevant and up-to-date with current industrial demands. Furthermore, the model includes rigorous stages of implementation and evaluation, conducted within industrial settings, which immerse students in real-world work environments. This not only bridges the gap between classroom learning and industry practice but also facilitates a smoother transition for students into the workforce.

According to C. Marnewick [58], H. Yudiono, S. Maulana, M. B. R. Wijaya et al. [59], and G. Pan, P.-S. Seow, V. Shankararaman et al. [60], in the i-SDPL learning model, the integration of project- and product-based learning with industry standards is essential in shaping students' competencies to meet industry needs. By working on real industrial projects, students gain practical experience and develop skills that can be directly applied in their future careers. This experiential learning approach not only improves technical proficiency, but also encourages critical thinking, problem-solving and collaboration skills. Exposure to the industrial climate plays an important role in preparing students for the professional environment by enhancing their understanding of industrial processes and work culture. This comprehensive exposure helps develop the character and work readiness of vocational high school (VHS) students, making them more adaptable and able to face the challenges of the modern industrial landscape. The i-SDPL model, therefore, represents a significant advancement in vocational education by ensuring that students are not only academically proficient but also industry-ready.

According to A. Saepudin [61], the i-SDPL learning model has been shown to be highly effective in improving work readiness across multiple dimensions, including attitude, knowledge and skills. The model significantly improves competence in the attitude of rigour. The statement is supported by H. B. Issa and A. Khataibeh [62], who state that project-based learning is a core component of the i-SDPL model that emphasises the final quality of the product. To achieve a high-quality product, students must pay careful attention to every detail and ensure that each step is done carefully, thus consistently developing attitudinal competence in the aspect of rigour. In addition, G. Aydın, O. Mutlu [63] and U. Usmeldi, R. Amini [64], stated that the i-SDPL learning model is an effective method to foster competence in teamwork. Student collaboration/cooperation in producing products/projects forms student competence in discussion and provides different knowledge.

According to Z. Zen, Reflianto, Syamsuar et al. [65], L. Zhang, Y. Ma [66] and T. Q. Tran, T. N. P. Tran [67], work competence and discipline refer to a person's ability to complete tasks on time with high quality standards. Through the application of the i-SDPL learning model by producing projects or products, students can create work that meets industry standards, which emphasise completeness, efficiency and perfection. By applying i-SDPL consistently, an optimal attitude of hard work and discipline will be formed. The next attitude competency is creativity and innovation. According to S. Hanif, A. F. C. Wijaya, N. Winarno [68], S. K. Ummah, A. Inam, R. D. Azmi [69], and A. Ahmad, B. Jabu [70], the application of i-SDPL will strengthen students' creativity and innovation attitudes. In the process of making products, students repeatedly receive input/direction from industry practitioners and teachers. The process encourages students to always innovate, looking for new ways to improve the quality of the products they produce, so that their creativity and innovation competencies are growing.

Motivational factors for all participants in the i-SDPL model include aspects from students, teachers, and industries involved in the learning process. The i-SDPL learning model stimulates students to understand and apply concepts and theories in product manufacturing. The question is supported by Syahril, Purwantono, R. E. Wulansari et al. [71] and M. H. Shin [72], that through the i-SDPL learning model, students more easily understand the relevance and importance of technical knowledge in practical applications. Not only that, this model also facilitates students to experience firsthand the process and challenges of completing a project or product.

This activity encourages students to develop technical skills from planning, implementation, to evaluation. In addition, the i-SDPL learning model improves students' material knowledge competence. This is supported by research conducted by N. Wijayati, W. Sumarni, S. Supanti [73], E. C. Miller, J. S. Krajcik [74], and M. Nasir, R. Fakhrunnisa, L. R. Nastiti [75], which showed that learning with the i-SDPL model can shape students' attitudes, knowledge, and work skills as a whole. Through this model, students not only understand the theory, but can also directly observe how these concepts are applied in making real projects or products. The integration of product-based learning models with industry allows students to gain practical experience in the use and processing of materials, so that they are better prepared to face challenges in the world of work.

For teachers, motivation comes from their role as facilitators who not only teach theory but also guide students in industry-based projects. This model allows teachers to update their insights through co-operation with industry as well as develop more innovative and effective learning methods. In addition, students' success in producing quality projects is a source of satisfaction for educators. For the industry, involvement in SDPL is an opportunity to get a more prepared and skilled workforce candidate according to the company's needs. By participating in the design and evaluation of projects, industries can ensure that graduates have competencies that meet their standards. In addition, this model also helps the industry to build close relationships with educational institutions, which can lead to wider cooperation in the future.

Mechanical skills competence refers to a person's practical ability to understand, maintain, repair and operate machine tools and components. The i-SDPL learning model is developed in accordance with industry needs and standardisation. Through the application of the model, students get the opportunity to apply the theory and concepts of machining in making projects or products. This question is in accordance with the results of research from W. Kurniawan, A. Budiono [76], H. Maksum, W. Purwanto [77], C. Y. Chao, Y.-C. Li, M.-S. Hour et al. [78], and S. Syahril, R. A. Nabawi, D. Safitri [79], who stated that by working according to industry standards, students can understand how the principles of mechanics apply in a real industrial context. S. Syahril, R. A. Nabawi, D. Safitri [79], J. Zhang, W. Wu, H. Li [80], H. Suswanto, A. Hamdan, R. R. Mariana et al. [81], M. D. C. Granado-Alcón, D. Gómez-Baya, E. Herrera-Gutiérrez et al. [82], stated that the project-based learning model integrated with industry can improve the competence of information technology skills. The statement is supported by V. J. Llorent, A. L. González-Gómez, D. P. Farrington et al. [83], and A. M. Al-Abdullatif, A. A. Gameil [84], that through the completion of industry-standard projects or products, students have the opportunity to interact with various tools, platforms and information technology commonly used in the industrial world. This learning activity equips students with practical and technical skills in operating, maintaining, and utilising various solutions using information technology.

The i-SDPL model has several limitations that can affect its effectiveness. One of the main challenges is the limited collaboration with industry, especially for schools that do not have easy access to relevant companies. This can be overcome by building a wider network of partnerships through internship programmes, curriculum cooperation and industry visits. In addition, limited resources and infrastructure in some schools are also an obstacle in implementing this model. Solutions that can be applied are the utilisation of simulation technology, cooperation with companies for access to industrial facilities, and procurement of equipment through educational grants.

On the other hand, students' level of independence in learning varies, which can affect the smooth running of their projects. To overcome this, initial training on project management, more intensive guidance from teachers and industry mentors, and periodic evaluations are needed to ensure students' progress. In addition, the evaluation of competency standards is also a challenge due to differences in industry standards that may affect the objectivity of the assessment. Therefore, the development of a standardised assessment rubric with the industry is a solution to ensure a more accurate evaluation and in accordance with the needs of the world of work. An explanation of these limitations and their solutions can be included in the Discussion section to provide insight into the challenges of i-SDPL implementation and strategies to improve its effectiveness.

Conclusion

The i-SDPL learning model is an innovative approach derived from the Project-Based Learning (PjBL) framework. The development of this model stems from a comprehensive needs analysis and feedback from industry experts and practitioners. The distinguishing feature of the i-SDPL model is the integration of industry involvement at every stage of the learning process, including preparation, implementation, and evaluation. Moreover, the i-SDPL model is executed in a blended format, combining learning experiences in vocational high schools (VHS) and industry settings. The industry component is designed to acquaint students with the professional work environment at an early stage.

The i-SDPL learning model has demonstrated its efficacy in enhancing competencies in attitude, knowledge, and work skills through two trial implementations. The implementation of the model is intended to benefit not only students but also teachers. For educators, the i-SDPL model serves as a mechanism to update and expand their knowledge in line with current industry advancements.

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