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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.

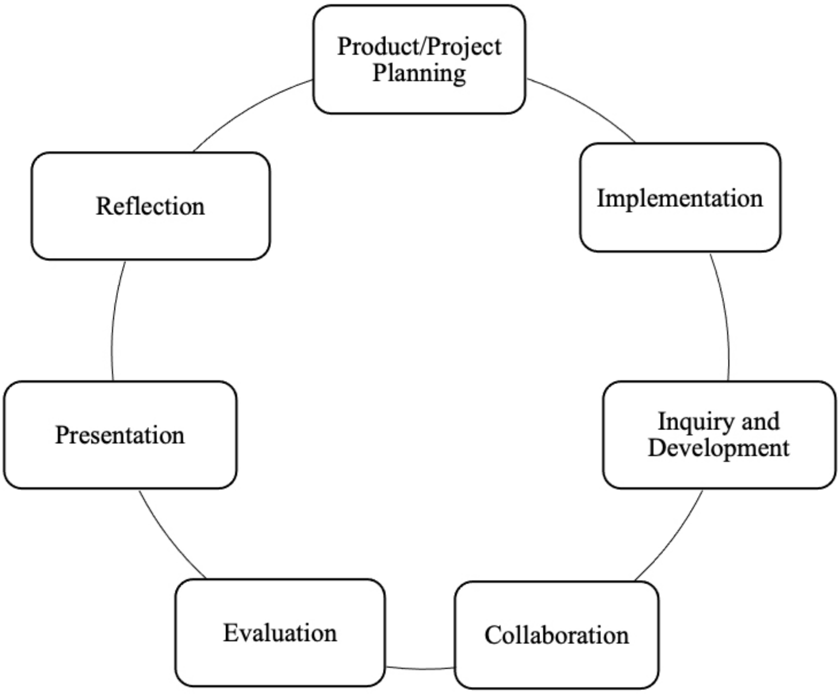

Fig. 1. Stages of the Self-Design Project Learning (SDPL) model

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.

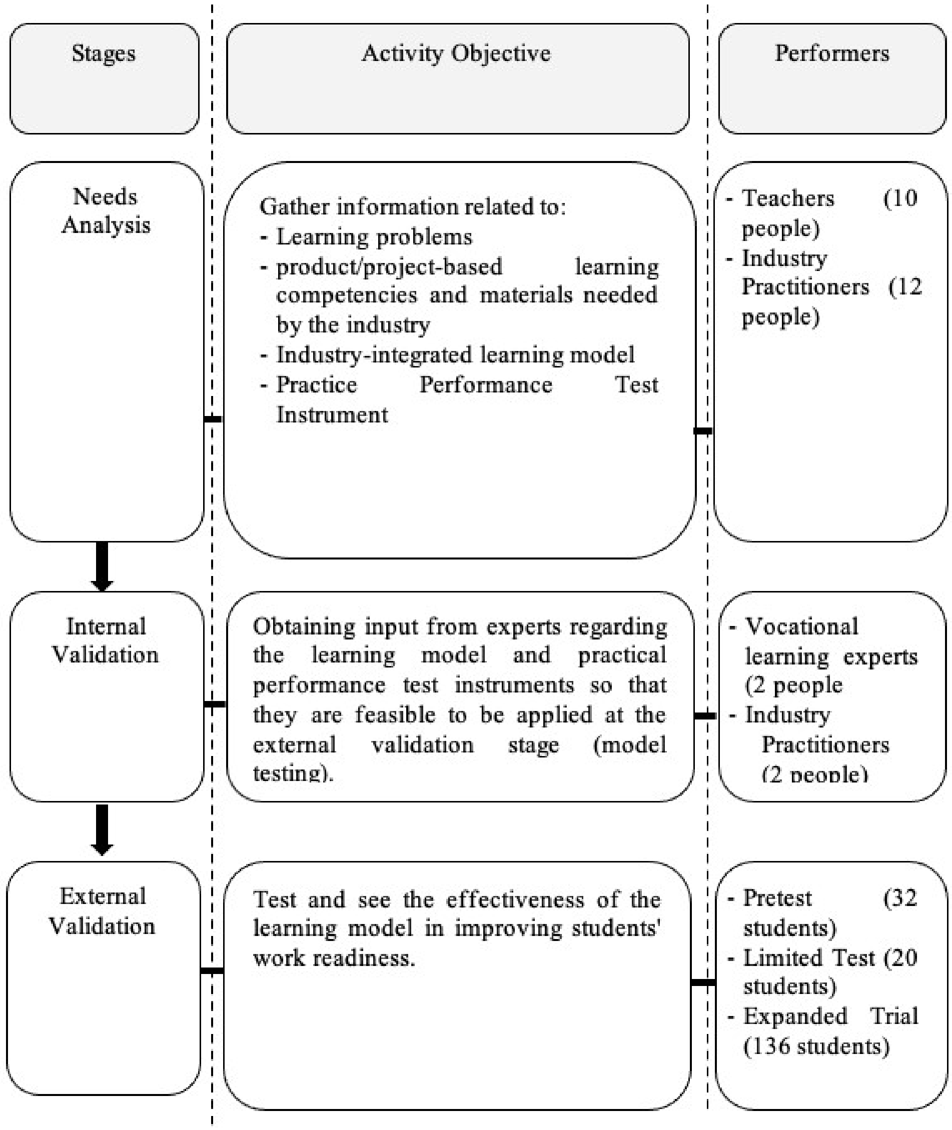

Fig. 2. Research and development procedures

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.

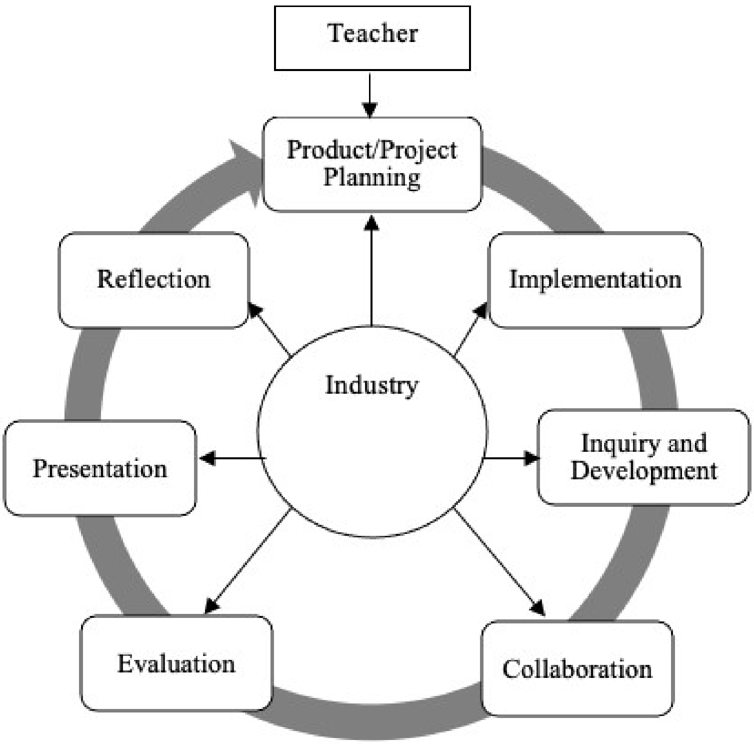

Fig. 3. i-SDPL model from needs analysis (conceptual)

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.

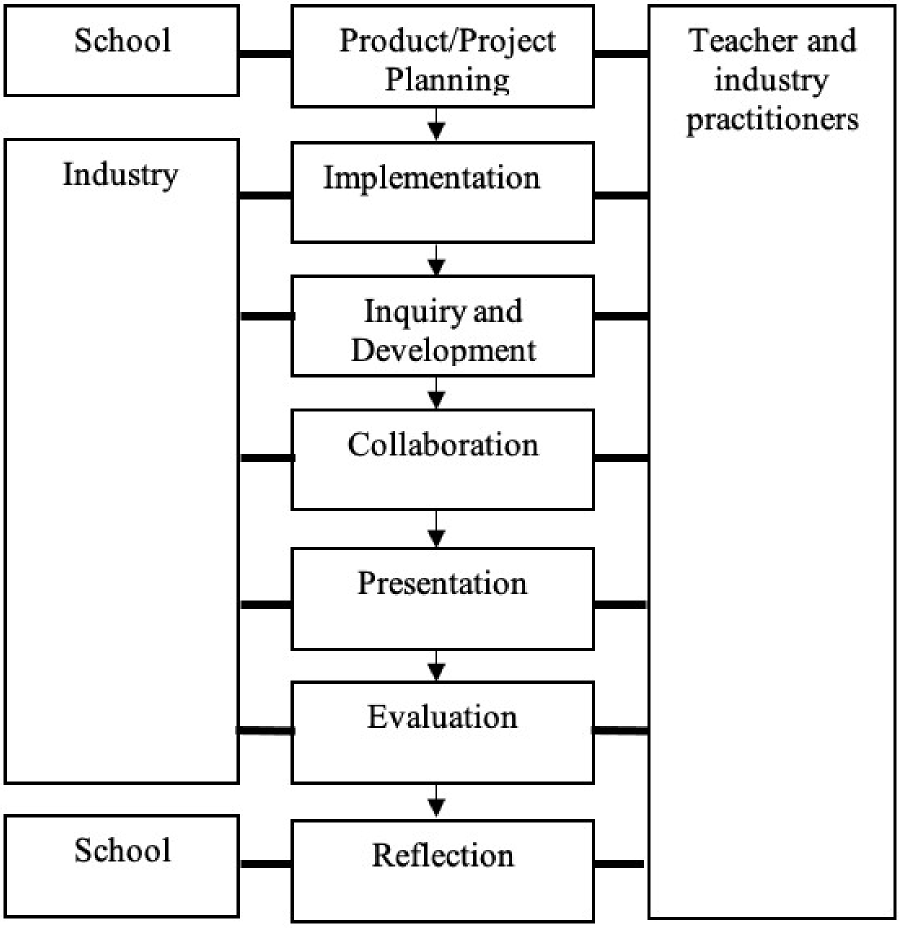

Fig. 4. Implementation of i-SDPL model

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.

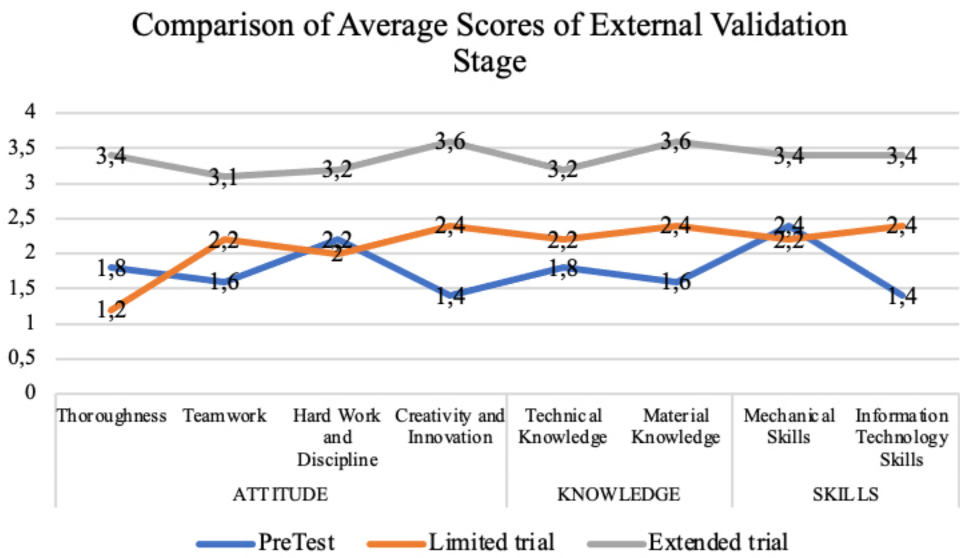

Fig. 5. Comparison of average scores of external validation stage

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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