

Integration of Industry-Based Learning and an Interdisciplinary Approach in the Machine Tools Course to Enhance the Competencies and Work Readiness of Vocational Education Students

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ABSTRACT

Vocational education must respond to rapid industrial changes, particularly in the Industrial Revolution 4.0 and Society 5.0 era. This study investigates the integration of Industrial-Based Learning (IBL) and an interdisciplinary approach to enhance students' competence, work readiness, and graduate relevance. A mixed-method design was employed, combining descriptive quantitative analysis and qualitative case studies. Findings show that learning implementation achieved the highest mean score (14.57), indicating highly positive and consistent student perceptions. Learning preparation and evaluation obtained mean scores of 13.73 and 13.33, respectively, while evaluation displayed the greatest variation, suggesting the need to strengthen feedback mechanisms. IBL effectively improves student engagement, motivation, and technical competence through industrial internships, teaching factories, and project-based learning. The interdisciplinary approach enhances critical thinking, creativity, and knowledge integration. Successful implementation depends on strong industry partnerships, continuous faculty development, and adaptive curriculum policies aligned with evolving workforce demands and technological advancements.

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Introduction

In the era of the Fourth Industrial Revolution, the demand for workers with practical and adaptive skills is increasing Ishara et al (2025). Industry-Based Learning (IBL) emerges as an innovative solution in the field of education, particularly in vocational education, by integrating industry experience into the learning process. This approach enables students to gain direct insights from industry professionals, enhance technical competencies, and develop essential skills such as problem-solving, teamwork, and communication Ilyas (2024). Despite the benefits it offers, the implementation of IBL faces challenges, such as low industry involvement in educational programs Hayati and Utomo (2024) and a lack of alignment between the curriculum and the needs of the workforce Agustian et al (2024). Nevertheless, various studies indicate that IBL significantly enhances students' learning motivation and readiness to enter the workforce Agustian et al (2024). Therefore, close collaboration between educational institutions, industry, and other stakeholders is key to optimizing the effectiveness of IBL.

Industrial learning encompasses various educational approaches that integrate practical experience in the industrial world, significantly improving students' competencies and problem-solving skills. This learning model is essential for bridging the gap between theoretical knowledge and real-world application, preparing students for successful careers in their respective fields. Industrial training (IT) plays a crucial role in technical education, providing hands-on experience that develops technical and soft skills, as evidenced by a 95.7% improvement in technical abilities among students Ling and Leong (2025). Additionally, IBL has been proven to enhance problem-solving skills among vocational students, with efficiency rates exceeding 80% Alongkrontuksin et al (2024). Experience-based learning in vocational schools also boosts student motivation and practical skills Fania et al (2024), driven by collaboration between educational institutions and industry. Despite its many benefits, challenges such as inconsistent industry exposure and curriculum alignment with industry demands still need to be addressed to maximize the effectiveness of IBL.

In the implementation of IBL, the interdisciplinary approach is a highly relevant method to integrate into the vocational learning process, particularly in the Machine Tools course. The interdisciplinary approach facilitates collaboration across various fields of study, such as manufacturing engineering, welding, technical drawing, workplace safety, production management, and digital technology, to solve real-world problems in the industrial sector. This approach is increasingly recognized as a key element in modern education because it fosters a learning process that is more holistic, adaptive, and contextually aligned with the needs of the workforce. According

to (Q. Zhou et al., 2024; Y. Zhou, 2024), an interdisciplinary educational model can enhance student motivation and learning psychology, particularly among students with diverse skill sets. Furthermore, Grasser and Mayer (2015) explain that interdisciplinary education in vocational education and training can improve students' competencies, deepen their understanding of the material, and encourage increased interest and motivation in learning.

In the context of vocational education, an interdisciplinary approach is a key strategy for fostering an industrial work culture, as students not only learn technical skills in isolation but also understand the interconnections between various fields of knowledge within industrial production processes (Didur, 2023; Holmbukt and Larsen, 2016). Vocational education has evolved toward interdisciplinary learning with a focus on student engagement, self-efficacy, work readiness, and labor market needs. This indicates that modern vocational education is no longer oriented toward a single area of competency but emphasizes the integration of various disciplines to support graduates' work readiness. Furthermore, Huang (2025) explains that collaboration between industry and academia, interdisciplinary integration, and competency-based education can enhance students' competitiveness and adaptability in meeting the demands of the modern workplace.

The importance of an interdisciplinary approach is also evident in the implementation of project-based learning and Industry 4.0 technologies. Interdisciplinary learning activities integrated with vocational education can encourage students to understand the impact of Industry 4.0 technologies on the workplace and social life, while also enhancing students' ability to identify problems and collaboratively propose (Eridheni et al., 2025; Vieira et al., 2022). Additionally, competency-based integrated learning can enhance students' analytical thinking skills, their ability to compare, and their capacity to summarize and connect various pieces of knowledge acquired during the learning process (Tytova, 2018; Zinchenko et al., 2020). This approach provides a more meaningful learning experience because students are directly exposed to simulations and real-world industry problems that require cross-disciplinary solutions.

Nevertheless, the implementation of an interdisciplinary approach in vocational education also presents challenges, particularly regarding communication, coordination across disciplines, and the adaptation of curricula and learning strategies Ummah (2022). The implementation of interdisciplinary science projects in vocational schools indicates that limitations in teacher competencies, inflexible curriculum design, and a lack of collaboration are the primary barriers to the implementation of interdisciplinary learning (Nur, 2024; Xu, 2025a). Nevertheless, through training, strengthened collaboration, and the development of adaptive curricula, the

interdisciplinary approach remains a promising strategy for improving the quality of vocational education and graduates' work readiness.

Thus, the integration of IBL and an interdisciplinary approach in the Machine Tools course not only serves as a solution for enhancing students' technical competencies but also plays a crucial role in instilling an industrial work culture, such as discipline, collaboration, responsibility, problem-solving, and the ability to adapt to technological advancements. Through collaboration between universities, industry, and various academic disciplines, the implementation of industry-based learning is expected to bridge the gap between the worlds of education and work and produce graduates who are better prepared, more professional, and more competitive in the era of the Fourth Industrial Revolution.

Method

The research method used in this study employs two approaches, namely: (1) descriptive quantitative analysis to examine the results of learning improvement, and (2) qualitative analysis using case studies to review in depth the integration of industrial-based learning and an interdisciplinary approach in machine tool courses to instill an industrial work culture. The subjects of this study were students enrolled in the Machine Tools course. The study included a total of 30 students. The sampling technique used was total sampling, in which all students enrolled in the course were included as the study sample because the population size was relatively small and all students were directly involved in the learning process. This technique ensured the data accurately reflected the implementation of IBL and the interdisciplinary approach.

Descriptive Quantitative Analysis

Then, a descriptive quantitative approach was conducted using a questionnaire accessed at (https://docs.google.com/forms/d/e/1FAIpQLSdLtcVfuv955fG4Lp_5lDg9Lu5_H8yNdGVymB1dL_X2jqJhw/viewform?usp=dialog). The results of the questionnaire validity test are explained in Table 1. At the end of the study, the conclusions from the research results will be discussed further with relevant literature. Questionnaire on the Implementation of IBL explain in Table 1.

Table 1. Questionnaire on the Implementation of IBL

No	Question Instrument	Validity Score	Validity Results
1	Instrument 1	.641**	Valid
2	Instrument 2	.570**	Valid
11	Instrument 11	.772**	Valid
12	Instrument 12	.681**	Valid

Reliability is measured using Cronbach's Alpha. If reliability produces a value > 0.6 , then the data is considered reliable. The reliability test results obtained were 0.971, so the questionnaire instrument is considered reliable. Reliability Statistics explain in Table 2

Table 2. Reliability Statistics

<i>Cronbach's Alpha</i>	<i>N of Items</i>
0.971	12

The questionnaire was developed using a Likert scale with four score levels. Likert scale explain in Table 3.

Table 3. Likert scale

<i>Score</i>	<i>Category</i>
4	Strongly Agree (SS)
3	Agree (S)
2	Disagree (TS)
1	Strongly Disagree (STS)

The analysis was conducted by calculating the mean, median, mode, standard deviation, minimum value, maximum value, and range. To reinforce the results, frequency distribution tables and the F-average were also used, which were calculated from the multiplication of the frequency and the median value of each interval, then divided by the number of respondents. This analysis aims to identify trends in student assessments and aspects of learning that still need improvement.

Qualitative data analysis

In qualitative research, the case study method is used to identify issues based on real-world data involving multiple research subjects. The qualitative research method was chosen because it allows for an in-depth exploration of the implementation of IBL and interdisciplinary approaches in the learning process of the Machine Tools Practicum course in the Department of Mechanical Engineering Education at Universitas Negeri Makassar. This approach emphasizes understanding the meaning, processes, experiences, and social interactions that occur during the learning process. The case study approach was chosen because the research focus is directed intensively and deeply at a specific phenomenon, thereby providing a comprehensive picture of the implementation of IBL and interdisciplinary learning.

The researcher's presence at the research site in a qualitative research framework requires the researcher to be physically present in the field as the primary instrument (human instrument) in the data collection process (Hollweck, 2016; Ulfatin, 2015). The researcher conducted observations,

in-depth interviews, documentation, and the collection of other supporting data to obtain accurate and comprehensive data. The data sources in this study consist of the Head of the Mechanical Engineering Department, the Head of the Mechanical Engineering Study Program, lecture, and students enrolled in the Machine Tool Practicum course.

The data collection methods used in this study include in-depth interviews, observation, documentation, and questionnaires. In-depth interviews were conducted to gather information regarding the implementation, benefits, and impact of IBL and interdisciplinary approaches. Observation was used to directly observe the learning process, student interactions, and faculty engagement during the practicum. Documentation was carried out through the collection of photos, portfolios, and supporting learning documents. Meanwhile, questionnaires were used to obtain data on students' perceptions of the implemented learning methods.

The steps taken by the researcher are described in Figure 1, which include: (1) data reduction, namely the process of selecting, simplifying, and focusing the data in accordance with the research objectives; (2) coding the research focus based on research categories and indicators; (3) systematic presentation of data in the form of narratives, tables, and descriptions of research results; and (4) drawing conclusions and verifying data based on field findings. Data analysis and validity checks were conducted using credibility through source triangulation and method triangulation techniques. Source triangulation was conducted by comparing interview data from various informants, while method triangulation was conducted by comparing the results of interviews, observations, documentation, and questionnaires. Data analysis began with individual cases and was followed by cross-case analysis to identify patterns, correlations, and general conclusions regarding the implementation of IBL and the interdisciplinary approach. Interactive Cycle of Research Data Analysis Process explain in Figure 1.

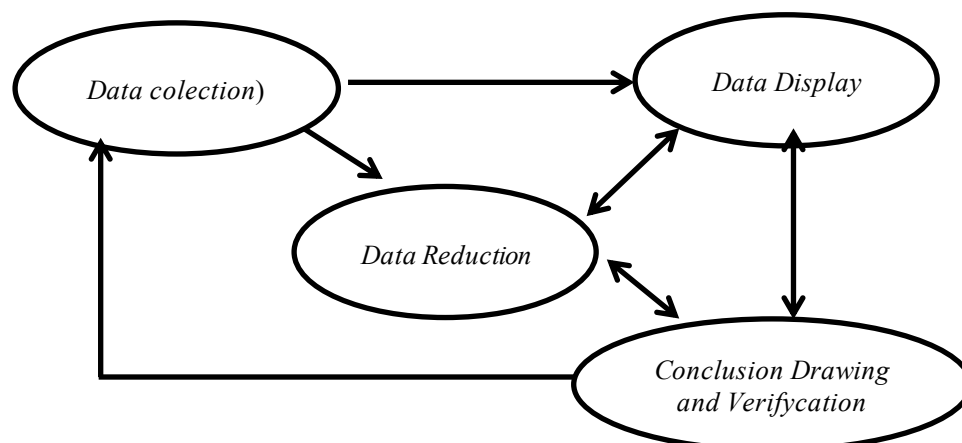


Fig 1: Interactive Cycle of Research Data Analysis Process

The research data and data collection indicators are explained in Table 4.

Table 4. Guidelines for Data Collection and Coding

No.	Research Indicator	Code	Data Collection Technique	Code	Data Source	Code	Reduction Results
1.	Implementation of IBL and Interdisciplinary Learning (Preparation, Implementation, and Evaluation of Learning)	PeBI	In-depth interviews	WM	Head of Department	KJ	PeBI-WM-KJ
					Head of Study Program	KK	PeBI-WM-KK
					Welding Lecturer	DP	PeBI-WM-DP
					Student 1	MHS1	PeBI-WM-MHS1
					Student 2	MHS2	PeBI-WM-MHS2
			Observation Documentation Questionnaires	O D A	Portfolio Data	P	PeBI-O-P
					Photo	F	PeBI-D-F
					Student	M	PeBI-A-M
					Head of Department	KJ	IBL-WM-KJ
					Head of Study Program	KK	IBL -WM-KK
2	Impact, Benefits, and Implementation of IBL	IBL	In-depth interviews	WM	Head of Department	KJ	IBL -WM-KK
					Head of Study Program	KK	IBL -WM-KK
					Welding Lecturer	DP	IBL -WM-DP
					Student 1	MHS1	IBL -WM-MHS1
					Student 2	MHS2	IBL -WM-MHS2
			Observation Documentation	O D	Portfolio Data	P	IBL -O-P
					Photo	F	IBL -D-F
					Head of Department	KJ	IN-WM-KJ
					Head of Study Program	KK	IN -WM-KK
					Welding Lecturer	DP	IN -WM-DP
3.	Impact, Benefits, and Interdisciplinary Approaches	IN	In-depth interviews	WM	Head of Department	KJ	IN -WM-KK
					Head of Study Program	KK	IN -WM-KK
					Welding Lecturer	DP	IN -WM-DP
					Student 1	MHS1	IN -WM-MHS1
					Student 2	MHS2	IN -WM-MHS2
			Observation Documentation	O D	Portfolio Data	P	IN -O-P
					Photo	F	IN -D-F
					Head of Department	KJ	IN-WM-KJ
					Head of Study Program	KK	IN -WM-KK
					Welding Lecturer	DP	IN -WM-DP

In addition, to enhance the validity of the research findings, the researcher also conducted member checking with the research informants to ensure that the data and interpretations obtained were consistent with the actual conditions in the field. This study employed a case study approach, so data analysis was conducted in depth for each case identified in the implementation of IBL and the interdisciplinary approach in Machine Tool Laboratory courses. Data analysis began with individual cases and was followed by cross-case analysis to identify similarities, differences, and patterns in the implementation of the learning process. Through this case study approach, the research is expected to yield more contextual, in-depth, and comprehensive findings regarding the implementation, benefits, and impacts of IBL in the Department of Mechanical Engineering Education at Universitas Negeri Makassar.

Result and Discussion

Descriptive Results

Implementation of IBL and Interdisciplinary Approach

The results of the study point to the implementation of learning reviewed in three main aspects, namely: Learning Preparation, Learning Implementation, and Learning Evaluation and Impact. The results of descriptive statistical analysis of 30 respondents are presented in Table 5.

Table 5. Summary of Descriptive Statistics for Each Aspect

<i>Indicator</i>	<i>Mean</i>	<i>Median</i>	<i>Mode</i>	<i>SD</i>	<i>Min</i>	<i>Max</i>	<i>Range</i>	<i>N</i>
Learning Preparation	13.73	15	15	2.16	6	16	10	30
Learning Implementation	14.57	14.55	16	1.94	7	16	9	30
Evaluation and Impact	13.33	14.5	16	2.43	6	16	10	30

A descriptive analysis of the learning outcomes of students who received face-to-face learning and students who received online learning was processed to obtain a descriptive distribution of learning outcomes in both classes according to learning preparation, learning implementation, evaluation, and impact, as presented in Table 5. Indicating that the data distribution for each aspect is not too far from its average value. In other words, students' perceptions tend to be homogeneous or consistent across these aspects.

Based on the results of the study and expert opinions, it can be concluded that IBL preparation and an interdisciplinary approach aim to directly involve students in searching for, exploring, and determining the steps involved in creating a product. Furthermore, based on the results of the questionnaire on the role of learning preparation, the tabulated data is explained in Table 6.

Table 6. Average F-score for Lesson Preparation

<i>No</i>	<i>Interval</i>	<i>F</i>	<i>Median Value (X)</i>	<i>FX</i>
1	6-7	2	6.5	13
2	8-9	1	8.5	8.5
3	10-11	2	10.5	21
4	12-13	7	12.5	87.5
5	14-15	8	14.5	116
6	16-17	10	16.5	165
	N	30		411
		F		13.7

Table 6 shows that the average F score is 13.7, meaning that learning in terms of preparation shows that most students rate the preparation of lecturers, materials, and lesson plans prepared before implementation as good. This reflects that the planning carried out is in line with student expectations. Furthermore, based on the results of the learning implementation questionnaire, the tabulated data results are explained in Table 7.

Table 7. Average F for Learning Implementation

<i>No</i>	<i>Interval</i>	<i>F</i>	<i>Median Value (X)</i>	<i>FX</i>
1	7-8	1	7.5	7.5
2	9-10	2	9.5	19
3	11-12	4	11.5	46
4	13-14	8	13.5	108
5	15-16	15	15.5	232.5
	N	30		413
		F		13.76667

Table 7 shows that the average F score is 13.7667, which means that students consider the learning process to be quite optimal. The delivery of material, lecturer-student interaction, and active learning activities are considered positive and supportive of the achievement of learning objectives. Furthermore, based on the results of the evaluation questionnaire and the impact of the tabulated data described in Table 8.

Table 8. Average F evaluation and impact

<i>No</i>	<i>Interval</i>	<i>F</i>	<i>Median Value (X)</i>	<i>FX</i>
1	6-7	3	6.5	19.5
2	8-9	3	8.5	25.5
3	10-11	4	10.5	42
4	12-13	8	12.5	100
5	14-15	7	14.5	101.5
6	16-17	5	16.5	82.5
	N	30		371
		F		12.36667

Table 8 shows that the average F score is 12.3667, which is lower than the other averages. This indicates that students feel that aspects of evaluation such as feedback, assessment, and learning outcomes still need to be improved. This could be a concern for lecturers or institutions in order to strengthen learning outcomes and learning continuity.

Qualitative Data Results

Industrial Based Learning

Based on an analysis of interview data, documentation, and observations, it was found that IBL in vocational higher education aims to bridge the gap between graduate competencies and industry needs. This learning model emphasizes collaboration between educational institutions and industry so that graduates are ready to work, relevant to technological developments, and able to compete in the labor market. The main challenges of IBL include limited facilities, a lack of industry experience among faculty/instructors, and a mismatch between the curriculum and industry needs. Proposed solutions include industry-based teacher training, strengthening collaboration, updating the curriculum to align with industry needs, and leveraging technology such as adaptive e-learning. The impacts of implementing IBL are outlined in Table 9 below.

Table 9. The Impact of Industrial-Based Learning

No.	Impact of IBL	Description	Code Data
1.	Improved problem solving	Students are trained to think critically and analytically in solving real-world problems that are contextual to the industrial world. Through the IBL approach, they become accustomed to identifying problems, designing solutions, and evaluating various alternative solutions. This strengthens their problem-solving skills, which are one of the key competencies in the era of Industry 4.0 and 5.0.	IBL-WM-KJ IBL-WM-KK IBL-WM-DP MHS1 IBL-WM-
2.	Increased work readiness	IBL-based learning enables students to experience real-world work scenarios directly. Through involvement in real projects and active learning, they gain practical understanding, soft skills, and professional attitudes required by the industry. This makes graduates more prepared and able to adapt quickly when entering the workforce.	MHS2 IBL-O-P IBL-D-F
3.	Campus-industry collaboration	IBL encourages industry involvement in the learning process, whether as a source of problems, project mentors, or facility providers. As a result, the curriculum becomes more contextual and tailored to the real needs of the business and industrial world (DUDI). This creates synergy between campuses and industries, which improves the relevance and quality of vocational education.	

Based on a qualitative analysis, the findings indicate that the integration of Industrial-Based Learning (IBL) and an interdisciplinary approach in the Machine Tools course contributes to instilling an industrial work culture in students. The implementation of IBL fosters improved problem-solving skills, work readiness, and collaboration between the university and industry through learning based on real-world problems and professional work practices. Students also become more accustomed to working according to procedures, applying workplace safety, and understanding industry work standards. Furthermore, this approach helps students integrate technical skills, work attitudes, and problem-solving abilities in a cohesive manner. Although

challenges such as limited facilities, faculty members' lack of industry experience, and curriculum alignment remain, the implementation of IBL continues to demonstrate a positive impact on strengthening competencies, work culture, and the relevance of graduates to the needs of the industrial world.

The research findings also show that the implementation framework for IBL in vocational education in the field of mechanical engineering, specifically for the Machine Tools course, is illustrated in Figures 2 and 3, which depict the IBL implementation scenario and documentation of the learning process.

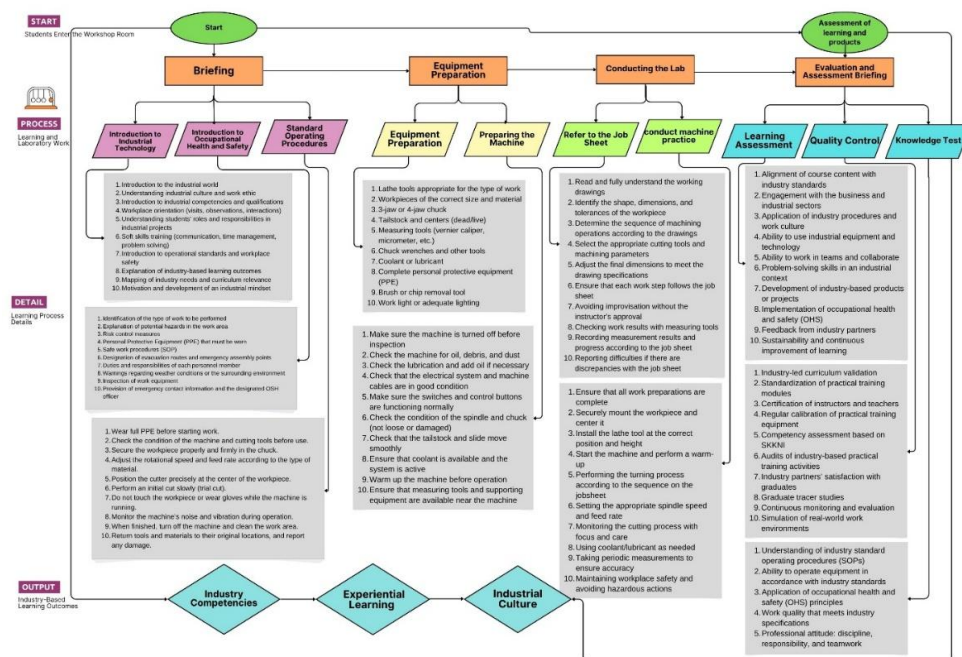


Fig 2: Implementation of IBL Learning and Interdisciplinary Approach in Machine Tools Course



Fig 3: Conducting a practicum with IBL

Interdisciplinary Approach

Based on the analysis of interview data, documentation, and observations, it was found that an interdisciplinary approach in vocational higher education is increasingly considered important in preparing graduates who are adaptive, innovative, and ready to face the demands of modern industry. The interdisciplinary education model has been proven to improve critical thinking, problem-solving, and collaboration skills, as well as strengthen the professional competencies of vocational graduates. The benefits of implementing an interdisciplinary approach are outlined in Table 10.

Table 10. Benefits and Implementation of an Interdisciplinary Approach

No.	Indicator	Key Findings	Data Code
1	Competency Development	Inquiry-based and project-based learning models have been proven to improve students' critical thinking skills, encourage cross-curricular or interdisciplinary integration, and foster a spirit of innovation in solving complex and contextual problems in line with industry needs.	IN-WM-KJ IN -WM-KK IN -WM-DP IN -WM-MHS1 IN -WM-MHS2
2	Work Readiness	Graduates demonstrate better work readiness thanks to learning that involves real-world contexts and interdisciplinary training. This prepares students to be more adaptive and flexible to the ever-changing dynamics and demands of the world of work.	IN -O-P IN -D-F
3	Teaching Methods	The use of IBL methods and interdisciplinary teamwork encourages collaboration among students and strengthens the integration of theory and practice. These methods are effective in creating an active, reflective, and productive learning environment.	
4	Evaluation & Adaptation	Regular evaluation of the curriculum and learning approaches is necessary to ensure alignment with technological trends and industry needs. Such adjustments are also important to maintain the relevance and sustainability of vocational education quality.	

Based on qualitative analysis, findings indicate that an interdisciplinary approach in vocational higher education plays a crucial role in enhancing students' competencies, innovation, and employability. This approach encourages students to think critically, solve problems in a contextual manner, and integrate knowledge from various courses or fields of expertise in line with industry needs. Additionally, the implementation of project-based learning, inquiry-based learning, and cross-disciplinary teamwork helps create an active, collaborative, and reflective learning environment. Students become more adaptable to technological changes and the demands of the workforce because they are accustomed to connecting theory with real-world practice. The success of implementing an interdisciplinary approach heavily depends on strengthening faculty capacity, adaptive curriculum design, regular learning assessments, and close collaboration between vocational institutions and the industry.

A Synthesis of the Results of Integrating Industry-Based Learning and an Interdisciplinary Approach in Vocational Education

Vocational education is required to be more adaptive to the ever-changing dynamics of industry, particularly in the face of the 4.0 and 5.0 industrial revolution era. Therefore, the integration of IBL with an interdisciplinary approach is a highly relevant and necessary strategy. Research findings related to the implementation of learning received the highest evaluation with an average of 14.57, standard deviation of 1.94, and mode of 16, indicating a highly consistent and positive perception among students regarding the learning process. The aspects of learning preparation and evaluation each had an average of 13.73 and 13.33, respectively; however, the evaluation aspect showed the highest standard deviation (2.43) and skewness of -1.639, indicating more varied perceptions and the need for attention to the quality of feedback and the impact of learning.

Furthermore, IBL in vocational higher education has been proven to improve the competence, work readiness, and relevance of graduates to industry needs. The success of IBL greatly depends on close collaboration between educational institutions and industry, curriculum renewal, and continuous training for lecturers and students. Research results on interdisciplinary approaches in vocational higher education have also been proven effective in improving student competence, innovation, and work readiness. The success of implementation depends heavily on strengthening faculty capacity, designing adaptive curricula, and maintaining close collaboration with industry.

The successful implementation of IBL in vocational education has proven to be effective in enhancing graduates' competencies, making them better prepared to enter the workforce. The implementation of WBL (Work-Based Learning) through industrial internships requires thorough planning, career orientation, and mastery of case studies as the primary foundation for the success of vocational education (Defris et al., 2024; Romadin et al., 2022; Sutiman et al., 2022). Additionally, learning approaches based on the 4th Industrial Revolution, such as the use of technology in the learning process, can prepare students to face the challenges of the modern job market (Dahl et al., 2023; Mazlan et al., 2024; Shevtshenko et al., 2019). IBL practices have also been proven to significantly improve the motivation and learning outcomes of vocational students, especially when supported by close collaboration between schools, government, and industry (Fania et al., 2024; Yoto et al., 2024). This is reinforced by findings (Jalinus et al., 2023) showing that WBL positively contributes to enhancing students' work readiness and benefits both educational institutions and industry.

Furthermore, IBL significantly improves the technical problem-solving skills of vocational students and produces workpieces or work products that meet industry standards Alongkrontuksin et al (2024). Learning models such as the teaching factory have also been proven to enhance graduates' competitiveness and readiness to face real-world work environments (Slamet et al., 2017; Tjiptady et al., 2020; Yoto and Widiyanti, 2017). Another study by Sudarsono and Pratama (2025) shows that the implementation of industry-oriented problem-based learning can increase learning engagement by up to 85% and raise students' average grades by more than 20%. With the support of an adaptive curriculum, cross-sector collaboration, and direct industry involvement, IBL emerges as an effective approach for producing vocational graduates who are not only competent but also relevant and responsive to the dynamic developments in the workplace.

Meanwhile, an interdisciplinary approach in vocational education has proven successful in improving students' critical thinking, problem-solving, and knowledge integration skills. Project-based interdisciplinary collaborative teaching models, such as those applied in English language teaching in vocational colleges, not only develop language skills but also cross-disciplinary collaboration skills (Xu, 2025; Y. Zhou, 2024). This approach is effective in producing graduates who are adaptable and relevant to the needs of the workforce, especially when linked to the trend of vocational education based on the New Liberal Arts Xu (2024). Wang (2024) notes that interdisciplinary task-based classes provide an advantage of over 7 points in critical thinking skills and knowledge integration.

Interdisciplinary approaches are also a strategic approach in vocational curriculum reform. According to (Q. Zhou et al., 2024; Y. Zhou, 2024) interdisciplinary education models can improve the learning psychology of students from different backgrounds and development plans. Gong (2024) and Zhang (2023) suggest that future vocational education curricula should include content updates, practical teaching, and interdisciplinary courses to support readiness for Industry 4.0 and 5.0. A study conducted by Huang (2025) confirms that this approach can enhance practical problem-solving skills among vocational students, with an interesting finding that female students demonstrate higher performance. On the other hand, Li (2024) and Kang and Zhang (2022) demonstrate that integrating general courses such as English with vocational skill courses can enhance both professional and academic competencies. This success is reinforced by the findings of Jacob (2015) that an interdisciplinary approach is crucial for preparing students to face the complexities of the workplace and future leadership.

The integration of IBL and an interdisciplinary approach in vocational education provides significant strategic benefits for the development of competent and adaptive human resources. The synergy between these two approaches produces graduates who are better prepared for the workforce, with a comprehensive understanding of the real needs of industry. Students engaged in interdisciplinary learning also tend to exhibit higher levels of creativity and innovation, as they are accustomed to thinking holistically and collaboratively in addressing complex challenges in the workplace. Additionally, this integration strengthens the relationship between vocational education institutions and the industrial world through joint curriculum development, the implementation of project-based internship programs, and the establishment of teaching factories as practical learning environments. This approach also strongly supports project-based learning (PBL) and product-based learning (PBL), as their success heavily relies on interdisciplinary collaboration to create real-world solutions. However, its implementation is not without challenges, such as the need to enhance faculty capacity in managing interdisciplinary learning, active industry involvement as equal partners, and the requirement for more flexible policies from educational institutions, particularly regarding curriculum design and adaptive evaluation systems that align with industry dynamics.

Conclusion

The integration of IBL and an interdisciplinary approach has proven to be an effective strategy in addressing the challenges of vocational education in the era of the 4th and 5th Industrial Revolutions. Data indicates that the implementation of this learning approach has received the most positive response from students (average 14.57), signifying the success of this approach in enhancing the learning experience. IBL consistently promotes the improvement of competencies, work readiness, and the relevance of graduates to the industrial world through curriculum collaboration, project-based internships, and teaching factories. Meanwhile, the interdisciplinary approach significantly contributes to the development of critical thinking skills, innovation, and the integration of knowledge across disciplines, thereby producing graduates who are adaptive, collaborative, and solution-oriented. The findings of this study, supported by current literature, reinforce the conclusion that the success of both approaches is greatly influenced by education-industry synergy, continuous training for faculty, and flexible and contextual curriculum design and evaluation. Therefore, strengthening institutional capacity, faculty, and responsive policies are key to ensuring the sustainability and maximum impact of integrating IBL and interdisciplinary approaches in vocational education.

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