A Study on the Gap Between the Competencies of Industrial Engineering Undergraduate Students and the Competency Requirements of the Job Market in Indonesia

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Abstract
This study examines the gap between industry expectations in Indonesia and the current competencies of undergraduate Industrial Engineering students at Universitas Sebelas Maret. The findings of this study can serve as a guideline for improving the existing Industrial Engineering program at Universitas Sebelas Maret. The research employs web scraping methods to identify appropriate indicators for assessing competency requirements in Indonesia's industrial sector. The curriculum expert team of Industrial Engineering at Universitas Sebelas Maret reviewed these indicators. Thirty-one competency performance indicators were adopted and distributed via questionnaires to 33 industry employees and 91 Industrial Engineering students from Universitas Sebelas Maret to rate the competency indicators on a scale of 1-5. We collected data and analyzed it to determine the gap between industry expectations and the current competencies of the students. The results show a significant gap between the competencies of undergraduate Industrial Engineering students at Universitas Sebelas Maret and the demands of the industry in Indonesia across all analyzed variables. The competencies with the highest gap are in the variables of Information & Communication, with a gap value of 436.8. The Information & Communication variable relates to the scope of technical skills, information system design, and programming. Conversely, we found the lowest gap in the management variable, with a gap value of 261.6. These variables are cost analysis, organizational management, marketing, and product innovation, which indicate that student competencies in this area are closer to industry expectations. This study highlights the urgent need for curriculum adjustments better to align student competencies with Indonesia's industrial sector demands.

Keywords: gap study, Indonesian industry, engineering education, industrial engineer.

Introduction

With the rapid advancements in industry and technology, the need for corresponding competencies in the job market is constantly evolving and increasing. However, there are indications that graduates of undergraduate industrial engineering programs have not yet fully met the competency demands required by the industry. This discrepancy creates a gap between the competencies possessed by graduates and those needed in the workforce.

Competencies combine knowledge, skills, and attitudes necessary to perform a job effectively. Knowledge includes theoretical and practical information relevant to the field of work, skills encompass both technical and non-technical abilities applicable in real situations, and attitudes involve values, motivations, and behaviors that support optimal performance in the workplace. Good competencies enable individuals to complete tasks efficiently and adapt to changes, solve problems, and contribute to overall work quality improvement (Spencer & Spencer, 1993). The industry has specific competency standards that workers must meet to contribute optimally. Therefore, higher education institutions are responsible for preparing graduates who meet industry needs (Kadir, 2017).

The competency gap in Indonesia is evident from the high unemployment rate (BPS, 2023) and feedback from companies regarding the competencies of graduates. Factors contributing to this gap include curricula that are less relevant to industry needs, a lack of practical experience among students, and insufficient mastery of soft skills such as communication and teamwork (Susanto, 2020).

As a potential market, Indonesia has the fourth-largest population globally (BPS, 2023), with a growing middle class (World Bank, 2023). It opens significant opportunities for industrial products and services. On the other hand, the demographic bonus, with 70% of the population being of productive age, is a valuable human resource (BPS, 2023). Despite its vast potential, Indonesia's readiness to face industrial challenges still needs improvement. Collaboration between the

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government, industry, and academia is key to building an ecosystem that supports industrial development (Setiawan, 2021).

The Indonesian government has demonstrated its commitment by launching various programs and policies, such as Making Indonesia 4.0 (Ministry of Industry, 2018). These programs include accelerating infrastructure, promoting technology adoption, enhancing digital talent, and establishing supporting regulations to prepare a digital society.

However, implementing advanced technologies requires skilled human resources capable of quickly adapting to technological changes. Here, the role of higher education, particularly industrial engineering programs, becomes crucial. Industrial engineering plays a vital role in this era. Industrial engineering focuses on the design of integrated systems involving humans and technology to achieve efficient and effective goals (Suharso, 2018). Technological developments like the Internet of Things (IoT), big data, and artificial intelligence (AI) open new opportunities to enhance industrial efficiency and productivity.

The industrial engineering curriculum offers subjects such as systems optimization, supply chain management, simulation, and manufacturing technology, which are highly relevant to Indonesia's industrial development (Arifin, 2019). Additionally, the interdisciplinary skills possessed by industrial engineering graduates, such as understanding business processes and technical capabilities, make them valuable assets for companies seeking innovation and operational efficiency improvements. Industrial engineering professionals must adapt to new technologies and develop innovative solutions to meet industry needs (Wijaya, 2020).

We need to ensure that the competencies and skills of undergraduate Industrial Engineering students at Universitas Sebelas Maret meet industry competency demands. So, this research aims to identify the gap between the competencies of these students and the competency requirements of the job market in Indonesia. The main focus of this research includes determining the competency indicators needed in the industry and assessing the readiness level of Industrial Engineering students at Universitas Sebelas Maret to meet these challenges. This research will give the curriculum team members better insights regarding the necessary education and training to prepare a competent workforce to face industrial challenges (Nugroho, 2021).

The results of this study can be used as a reference for improving the Industrial Engineering curriculum at Universitas Sebelas Maret and provide strategic recommendations for higher education institutions and policymakers in developing educational programs more aligned with current industry needs. Thus, the contribution of industrial engineering programs will not only be limited to technological development but also include enhancing national industrial competitiveness and the economic well-being of Indonesia as a whole (Handayani, 2022).

In this study, we conducted a web scraping method for the Jobstreet job vacancy website to obtain competency indicators reflecting industry demands. We used these indicators to construct a questionnaire distributed to undergraduate Industrial Engineering students at Universitas Sebelas Maret. The curriculum team can use the research findings to analyze and understand the gap between the current competencies of students and industry demands. Hopefully, this research can aid in curriculum development for educational institutions and ensure that students meet the criteria of the industrial sector and possess the quality needed to drive the nation's economy efficiently in the industrial era (Putri, 2023).

Research Methods

Research Model

We modified the research model of Chaengpromma & Pattanapairoj (2022) to conduct this research. The research studied the gap between industry expectations and current competencies of Khon Kaen University's undergraduate industrial engineering in the context of the Industry 4.0 era in Thailand and provided guidelines for program improvement. The research identified indicators to assess readiness for Industry 4.0, with 17 industry experts validated using the Delphi method. The questionnaires were resulted from competency performance indicators distributed to 71 industrial plants and 60 newly graduated engineers.

This research uses web scraping from the job listing website to determine the competency performance indicators. The questionnaires were distributed to 33 industrial professionals and 91 last semester students. Figure 1 illustrates the research model.

Population and sample group

This research is a quantitative research study. The population of this study comprises industrial employees in Indonesia and students from the Industrial Engineering Department at Universitas Sebelas Maret. The students referred to are enrolled in the Undergraduate Program of Industrial Engineering at Universitas Sebelas Maret and have completed all required courses to accomplish the undergraduate thesis.

Research tool

The research tool was questionnaires for data collection. We divide the research into two parts: 1) screening of competency indicators by web scraping and 2) Gap analysis between industry expectations and the student's competencies.

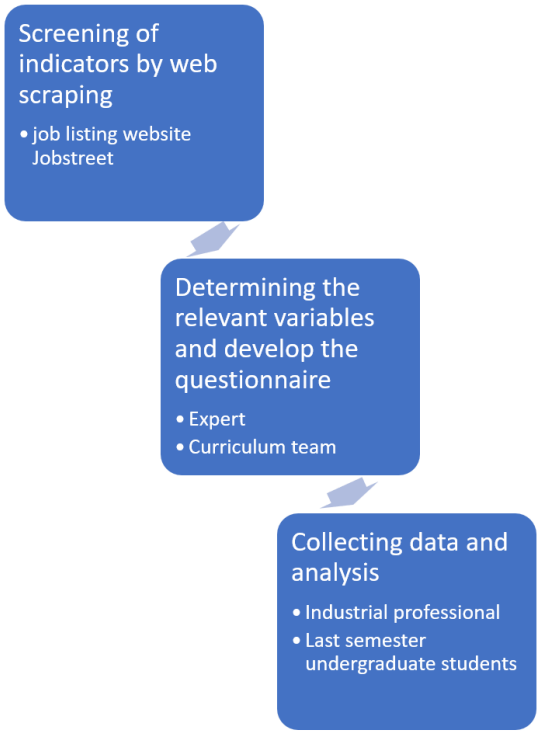

Figure 1. Research model illustration

1. *Screening of indicators by web scraping*

Identifying and determining indicators in this study involved several stages using web scraping from the job listing website Jobstreet, conducted via Jupyter Notebook on the Google Collaboratory platform. Initially, we collected data, cleaned it, and labeled it to ensure consistency, with similar competencies standardized and given uniform labels. Variable items were defined and identified based on expert opinions, followed by the identification and selection of relevant competency variables in consultation with the curriculum team of the undergraduate industrial engineering program. Each variable was assigned unique codes to facilitate systematic categorization and reference. These codes represented different sub-classifications under broader competency categories. Course learning outcomes outline the specific skills, knowledge, and attitudes that students will achieve upon completing individual courses. We developed statement items for the questionnaire considering the identified competency variables.

2. *Gap analysis between industry expectations and the Research tool*

We conducted a gap analysis to compare students' competencies with the Indonesian industry's demands. Data processing involved descriptive statistics and further analysis using SPSS. We conducted descriptive statistics to provide insights into respondents' work divisions and business sector frequency. The Mann-Whitney U Test, a non-parametric test, was then used to compare two independent groups' medians, as it is suitable for non-normally distributed data. This test helped determine if there were significant differences between the groups' medians, with hypotheses testing whether the medians were equal or different. We did a normality test beforehand to ensure the test's assumptions were satisfied.

Quality assessment of the research tool

After collecting data through an online questionnaire, the next step was to ensure the validity and reliability of the questionnaire using SPSS 25. Validity was tested by comparing the calculated R-value to the R table value at a 5% significance level. If the R-value exceeded the table value, the data was deemed valid. Reliability was confirmed with Cronbach's Alpha, where a value above 0.60 indicated that the questionnaire was consistent.

Results and Discussion

Analysis of Industry in Indonesia Competence Demand Indicators

We obtained 320 job vacancies related to industrial engineering, containing information such as job ID, job title, company name, company location, salary, job classification, and competencies in a comma-separated value (CSV) format. Of the 22 available classifications, the Manufacturing, Transportation, and Logistics category had the highest total frequency of 203 instances.

This category includes eight sub-classifications: Procurement, Procurement, & Inventory; Warehousing, Storage, & Distribution; Ergonomics; Management; Quality Assurance & Control; Information & Communication; Job, Assembly, & Processing; and Machine Operator. These sub-classifications were then developed into research variables based on competency-based curriculum (CBC) considerations and the curriculum team's feedback, as shown in Table 1.

Analysis of Industrial Engineering Undergraduate Students' Competence at Universitas Sebelas Maret and Industry in Indonesia Competence Demands

The data collection of the questionnaires sent to each sample group showed that the industries expected industrial engineering graduates to have high skill levels in all eight indicators. The sample of industrial engineering students in the case study university demonstrated moderate current skills in all areas, as seen in Table 2.

Table 1. Questionnaire Framework

Variables	Codes	Statements
Procurement, Procurement, & Inventory	PPI1	I feel that I understand the concepts and basic principles in designing efficient systems and processes.
	PPI2	I feel capable of applying analytical techniques to solve complex engineering problems.
	PPI3	I feel capable of collaborating with various departments to develop comprehensive industrial solutions.
	PPI4	I feel capable of implementing safety procedures in every industrial engineering project I undertake.
	PPI5	I am able to formulate operational problems into linear mathematical models that can be analyzed.
	PPI6	I can analyze relevant data and information to develop predictive models that support operational decision-making.
	PPI7	I feel capable of using analysis results to make optimal decisions related to company operations.
	PPI8	I am capable of developing operational policies based on in-depth data analysis and information processing.
Warehousing, Storage, & Distribution	PPD1	I can develop master production schedules based on sales forecasts and customer demand.
	PPD2	I understand production planning and scheduling to maximize operational efficiency.
	PPD3	I am capable of identifying and solving operational problems related to material management.
	PPD4	I can systematically compile reports and documentation related to inventory performance.
Ergonomics	E1	I am capable of understanding and applying basic ergonomic principles in designing effective work systems.
	E2	I can use anthropometric measurement tools to measure human body parts in work positions.
	E3	I understand human behavior in the context of industrial organizations to enhance productivity and employee well-being.
	E4	I am capable of designing efficient products, processes, or systems considering basic engineering principles.
	E5	I can identify, assess, and control hazards in the workplace by prioritizing handling sequences.
Management	M1	I can develop PPC systems, production strategies, quality procedures, and quality control (QC) to enhance operational efficiency.
	M2	I can comply with applicable industry standards and quality standards in production processes.
	M3	I can monitor sales performance to evaluate the effectiveness of applied sales strategies.
	M4	I am able to analyze market data and trends to improve efficiency and reduce operational costs.
	M5	I can control costs and improve production process efficiency through the application of economic techniques.
	M6	I am capable of implementing training programs for team development.

	M7	I feel capable of analyzing and understanding market trends and performing relevant analysis.
	M8	I can efficiently manage planning and scheduling of goods delivery in the supply chain.
	M9	I feel capable of actively participating in the development of innovative production strategies to enhance product efficiency and quality.
Quality Assurance & Control	PKM1	I feel capable of determining the appropriate probability distribution in the data collection process for statistical analysis.
	PKM2	I feel skilled in conducting production data analysis and processing to support informational decision-making.
	PKM3	I feel capable of implementing effective quality control in production processes.
	PKM4	I feel able to contribute to the development of innovative production strategies to improve quality and efficiency in industrial environments.
	PKM5	I feel capable of preparing comprehensive production quality reports and effectively documenting improvement results for future process enhancements.
Information & Communication	IK1	I feel skilled in using CAD software to design engineering products.
	IK2	I feel capable of developing information system applications (including information system programming and compiling Bill of Materials (BOM)) as needed by the industry to support operational and manufacturing efficiency.
	IK3	I feel capable of writing well and efficiently program code to meet information system needs in the industry.
Assembly & Processing Work	PPP1	I feel capable of understanding and determining standard machine elements and mastering process selection factors for effective product design.
	PPP2	I feel I have strong technical knowledge of products to support development and innovation in product design.
Machine Operator	OM1	I feel capable of understanding and operating machines effectively to support efficient production processes.
	OM2	I feel capable of understanding the basics of electronics and designing IoT systems to enhance automation in product design and operation.
	OM3	I feel skilled in designing mechanical systems that meet industrial specifications and needs to ensure optimal product performance.

Analysis of Competence Gaps of Industrial Engineering Undergraduate Students at Universitas Sebelas Maret Towards Industry in Indonesia Competence Demands

Based on the Mann-Whitney U test results, as shown in Table 3, all variables have p-values below 0.05. The results show we rejected the null hypothesis (equal medians between the two groups), suggesting a significant difference between the two test groups.

These findings reveal a significant gap in three variables: Information & Communication, Assembly & Processing Work, and Machine Operator. On the other hand, the variable with the lowest gap level is management. These results indicate a gap in all variables between industry expectations and the skills currently possessed by students, particularly in Information & Communication. This finding underscores the need for curriculum development that focuses more on these skills to ensure that graduates can meet the industry's evolving demands in the era of Industry in Indonesia.

Analysis Based on Categories of Average Score Differences between Student Competence and Industry in Indonesia Competence Demands

The analysis of differences between the average Industry in Indonesia's competence demands and the level of competencies among industrial engineering students using the Mann-Whitney U Test reveals significant differences across all eight categories at a significance level of 0.01. In all observed categories, the

significance value (Sig. 2-tailed) was 0.000, well below the 0.01 significance level, indicating statistical differences. The higher average values of industry expectations in Indonesia compared to student competencies suggest that the industry in Indonesia imposes higher demands than students' current capabilities.

These differences highlight a gap between industrial engineering students and expectations for industry in Indonesia. The Mann-Whitney U Test provides evidence that student competencies do not fully align with the industry demands in Indonesia, calling for improvements in curriculum and educational approaches to bridge this gap. As part of these improvements, variables showing significant gaps will be linked to competency-based curriculum (CBC) groups and aligned with course learning outcomes (CLOs).

This section presents significant research results. The analysis must also be conducted in detail on the results to support the research contribution. Moreover, a good discussion needs to compare the results obtained from other research.

Table 2. Industry in Indonesia Demands and Student Competencies

Industry 4.0 Demands and Student Competencies									
Variable	Industry 4.0			Students			Gap	Z	Sig. (2-tailed)
	Mean	Std. Dev.	Level of Demand	Mean	Std. Dev.	Level of Demand			
Purchasing, Procurement, and Inventory	32.13	2.78	High	24.73	4.487	Medium	333	-7.1855	0.000
Warehousing, Storage, and Distribution	15.88	1.601	High	12.51	2.557	Medium	303.3	-6.2612	0.000
Ergonomics	22.03	2.495	High	18.25	3.749	Medium	272.16	-5.1336	0.000
Management	38.81	4.238	High	32.27	6.154	Medium	261.6	-5.6903	0.000
Quality Assurance & Control	20.78	2.871	High	16.95	3.873	Medium	275.76	-5.2997	0.000
Information and Communication	12.09	1.027	High	8.45	2.731	Medium	436.8	-7.0452	0.000
Assembly & Processing Work	7.94	0.801	High	5.89	1.321	Medium	369	-6.881	0.000
Machine Operators	12.09	1.027	High	9.04	1.833	Medium	366	-7.2268	0.000

Table 3. The Result of Mann-Whitney U Test

Statistics Test[a]								
	Purchasing, Procurement, and Inventory	Warehousing, Storage, and Distribution	Ergonomics	Management	Quality Assurance & Control	Information and Communication	Assembly & Processing Work	Machine Operators
Mann-Whitney U	223.000	443.000	607.500	506.000	560.500	250.500	323.000	220.500
Wilcoxon W	4501.000	4721.000	4885.500	4784.500	4838.500	4528.500	4601.000	4498.500
Z	-7.186	-6.261	-5.134	-5.690	-5.300	-7.045	-6.881	-7.227
Asymp. Sig. (2-tailed)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
a.Grouping Variable: Category								

Table 4. Relationship Between Competencies and Course Learning Outcomes (CLOs)

Variable	Área of study	Course	Competency	Indicator	Relevance to CLOs
Information & Communication	Industrial System Design & Optimization	Technical Drawing Computer Programming	Composing Bill of Material	Technical Skill SI Design (System Information Design)	Technical Drawing Course No. 3 Computer Programming Course No. 2
			Using CAD software		
		Information System Analysis and Design	Writing program code	Programming Code Machine Understanding Product Knowledge	Computer Programming Practice Course No. 2 Mechanics Course No. 2 and Materials Engineering Course No. 1 Manufacturing Processes I Course No. 1-3
		Computer Programming Practice Technical Mechanics	Developing information system applications		
			Information System Programming		
		Material Engineering	Writing program code	Machine Operation	Machine Elements Course No. 1 and Manufacturing Processes II Course No. 1
Assembly & Processing Work	Product Planning & Design	Manufacturing Process I Machine Elements	Understanding standard machine elements	Automation Technical Skill	Automation Course No. 1-7 Technical Drawing Course No. 3
			Mastering mechanical system design		
		Manufacturing Process II Automation	Technical Product Knowledge		
			Customer Needs Analysis	SI Design (System Information Design) Programming Code Machine Understanding	Computer Programming Course No. 2 Computer Programming Practice Course No. 2 Mechanics Course No. 2 and Materials Engineering Course No. 1
		Production Aid Design Technical Drawing	Understanding machine operation		
			Mastering process selection factors		
			Product Presentation and Demonstration	Product Knowledge Machine Operation Automation	Manufacturing Processes I Course No. 1-3 Machine Elements Course No. 1 and Manufacturing Processes II Course No. 1 Automation Course No. 1-7
		Computer Programming	Understanding determination of standard machine elements		
Machine Operation		Information System Analysis and Design Computer Programming Practice	Understanding machine operation		
			Mastering process selection factors		
		Technical Mechanics Material Engineering Manufacturing Process I	Mastering automation technology	Technical Skill SI Design (System Information Design) Programming Code	Technical Drawing Course No. 3 Computer Programming Course No. 2 Computer Programming Practice Course No. 2
			Understanding electronics basics		
			Designing IoT systems		

		Machine Elements Manufacturing Process II	Improving operational efficiency	Understanding Machine	Mechanics Course No. 2 and Materials Engineering Course No. 1
			Mastering mechanical system design		
		Automation	Technical Product Knowledge		

Conclusion

This subsection concludes based on the research findings as follows:

1. This study found a significant gap between the competencies of undergraduate Industrial Engineering students at Universitas Sebelas Maret and the demands of the industry in Indonesia. The Mann-Whitney U test showed p-values below 0.05 for all variables, indicating significant differences. Furthermore, based on the hypothesis of mean competence, the average value of industry demands was higher than the upper limit of the interval for the variables, indicating high competency expectations from the industry. In contrast, the average competency value of the students was within the lower and upper interval limits, indicating a moderate level of competence. Therefore, the students' current competencies do not fully meet the industry demands in Indonesia.

2. Based on the gap values obtained, competencies with the highest to lowest gaps are ranked as follows: Information and Communication Variable; Assembly and Processing Work Variable; Machine Operator Variable; Purchasing, Procurement, and Inventory Variable; Warehousing, Storage, and Distribution Variable; Quality Assurance and Control Variable; Ergonomics Variable; and Management Variable. We found the highest competency gap in the Information and Communication Variable, which includes technical skills, information system design, and programming. Conversely, the variable with the lowest gap is management. The aspects covered in the Management variable include the scope of industrial, operational, and strategic elements within the industrial environment, aiming to improve efficiency, productivity, and company competitiveness.

Recommendation

This subsection provides recommendations for further research based on the research findings as follows:

1. The research findings indicate the need for curriculum improvements to bridge competency gaps, particularly in Information & Communication, Assembly & Processing Work, and Machine Operator. Curriculum adjustments should emphasize enhancing technical skills, information system design, programming, machine understanding, product knowledge, machine operation, and automation. Regular curriculum evaluations and stronger integration of digital technology and data analytics in relevant courses will enhance graduates' readiness to meet the challenges of Industry in Indonesia. The curriculum team should conduct periodic curriculum evaluations and stronger integration of technology and data analytics in relevant courses to enhance graduates' readiness to meet evolving industry demands.

2. Further research is recommended to utilize more diverse job search platforms to obtain more representative indicators of Industry in Indonesia. Additionally, for more objective outcomes, measuring student competencies should directly correlate with course grades to accurately depict how existing curricula prepare students to meet industry competency requirements.

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Conflict of Interest

The authors declare no conflict of interest.

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