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Analysis of Competency GAPs among Computer and Network Engineering (TKJ) Students in Relation to Industry Needs and Their Implications for Learning Technology Design

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Abstract

This study aims to analyze the competency GAP of Computer and Network Engineering (TKJ) students in relation to industry demands and to formulate its implications for instructional technology design. This study employs a mixed methods approach with an explanatory sequential design involving 31 twelfth-grade TKJ students who have completed their industrial internship (Praktik Kerja Lapangan/PKL). Quantitative data were collected through a Likert-scale questionnaire and analyzed using descriptive statistics and GAP analysis, while qualitative data were obtained from open-ended responses and analyzed using thematic analysis. The results show that TKJ learning has provided a strong foundation of basic competencies, particularly in preparing students for industrial internships and initial job readiness. However, competency GAPs remain in the integration of up-to-date industrial technologies and the depth of troubleshooting practices aligned with industry standards. The GAP analysis reveals that the highest GAPs occur in the discussion of current technologies (1.48) and troubleshooting skills based on industry standards (1.45). The findings of this study indicate that integrating quantitative GAP analysis with qualitative reflections from internship experiences provides a comprehensive empirical basis for developing adaptive, practice-based, and industry-aligned instructional technology design.

Keywords: Competency GAP, Vocational Education, Computer and Network Engineering, GAP Analysis, Instructional Technology Design, Industrial Internship

1. Introduction

The digital transformation in the era of Industry 4.0 and Society 5.0 has significantly reshaped workforce competency demands. The integration of technologies such as the Internet of Things (IoT), cloud computing, cybersecurity, big data, and artificial intelligence requires workers not only to possess basic technical skills but also to demonstrate adaptive abilities, problem-solving skills, and advanced technological literacy (Kemendikbudristek, 2022). In this context, vocational education plays a strategic role in preparing human resources that are aligned with industry needs, particularly through Vocational High Schools (SMK), which are mandated to ensure alignment between learning processes and the business and industrial sectors (DUDI).

The Indonesian government, through the vocational school revitalization program, emphasizes strengthening link and match through curriculum synchronization, project-based learning, competency certification, and industry collaboration (Direktorat SMK, 2021; Bappenas, 2023). However, the competency gap remains a major issue in vocational education. Data from the Central Statistics Agency (BPS, 2023) indicate that the unemployment rate among vocational school graduates remains relatively high, which is associated with the phenomenon of skills mismatch between graduates' competencies and labor market demands (ILO, 2022). In the field of information technology, gaps are evident in aspects such as industry-standard troubleshooting, mastery of industrial software, and the integration of complex network systems (Hidayat et al., 2022).

The rapid development of technology in the field of Computer and Network Engineering (TKJ), including networking devices, security systems, virtualization, and configuration automation, requires continuous updates in learning. The slow integration of industrial technologies into educational practices is one of the main causes of competency gaps (Rahmawati & Nugroho, 2023). In addition, industries also demand stronger non-technical competencies such as communication, teamwork, and critical thinking, where problem-solving and analytical thinking are considered key competencies for the future (World Economic Forum, 2023). Industrial internships (Praktik Kerja Lapangan/PKL) serve as an important instrument in bridging this gap through authentic experiences that enable students to understand industry work standards and reflect on their competencies (Lestari & Pratama, 2022). This is consistent with

UNESCO-UNEVOC (2021), which emphasizes the importance of industry-based experiential learning in enhancing the relevance of vocational education.

From a pedagogical perspective, project-based learning and problem-based learning have been proven effective in improving vocational competencies, as they encourage problem-solving that reflects real industrial conditions (Suryani et al., 2021; OECD, 2021), although their implementation still faces challenges related to infrastructure limitations, teacher readiness, and alignment with local industry needs (Bappenas, 2023).

Although numerous studies have examined the relevance of vocational education, most focus on curriculum evaluation or general job readiness. Studies that integrate quantitative competency gap analysis using the GAP approach with qualitative exploration of students' experiences as a basis for instructional design development remain limited, particularly in the TKJ field. In fact, such an approach is essential for generating recommendations based on empirical data and industry needs.

Based on these conditions, this study aims to analyze the competency gap of TKJ students in relation to industry needs, identify aspects with the highest gaps, and formulate implications for the development of instructional technology design. By integrating GAP analysis and reflections from internship experiences, this study is expected to provide an empirical foundation for designing adaptive, contextual learning aligned with industrial developments.

The novelty of this study lies in the integration of quantitative competency gap (GAP) analysis with qualitative reflections from internship experiences as a basis for developing instructional technology design. This approach produces a more comprehensive analysis compared to previous studies that generally treat these two aspects separately.

2. Literature Review

2.1. Vocational Education and the Challenges of Industry Relevance

Vocational education plays a crucial role in preparing a workforce with competencies aligned with industry needs; however, it faces challenges in maintaining the relevance of learning amid the rapid acceleration of digitalization and automation (Ministry of Industry, 2022). Data from the Central Statistics Agency (BPS, 2024) indicate that the unemployment rate among vocational high school graduates remains the highest compared to other educational levels, suggesting a mismatch between graduates' competencies and labor market demands (Sari & Hidayanto, 2021). In addition to curriculum alignment, industry relevance is also influenced by learning methods and practical facilities that have not fully met industry standards (Wibowo & Anwar, 2022).

2.2. The Concept of Competency GAP in Vocational Education

Competency gaps in vocational education arise from the imbalance between technological advancements and the adaptation of learning processes (Mulder, 2020). Studies indicate that the primary gaps in the field of computer networking lie in real-case-based troubleshooting skills, configuration of industrial devices, and the use of professional tools (Prasetyo & Kusumawardani, 2023). This is further supported by findings that learning still tends to focus on basic procedures, while industry demands more complex system analysis capabilities (Andriani et al., 2022).

At the international level, CEDEFOP (2020) emphasizes the importance of data-driven evaluation to continuously identify competency gaps. In this context, GAP analysis is considered an effective approach to map the differences between actual and ideal conditions and to determine priorities for instructional development (Tarigan & Sinaga, 2021).

2.3. The Role of Industrial Work Practice in Identifying Competency GAPs

Industrial internships (Praktik Kerja Lapangan/PKL) provide authentic experiences that enable students to understand industry work standards and reflect on their competencies (Nugraha & Setiawan, 2021). PKL also functions as an indicator for evaluating the relevance of learning, where students' perceptions can be used to identify discrepancies between school materials and industry needs (Yuliana & Firmansyah, 2022).

In the field of Computer and Network Engineering (TKJ), internship experiences reveal significant differences in the complexity of equipment, security standards, and the need for real-case-based troubleshooting, making PKL an important data source for analyzing competency gaps.

2.4. Learning Technology Design in the Computer and Network Engineering (TKJ) Program

Instructional design in the Computer and Network Engineering (TKJ) program needs to integrate pedagogical strategies and technology in a contextual manner. Project-based learning and industry simulation have been proven to enhance students' problem-solving abilities and technical competencies (Herlina & Subekti, 2020; Mahendra & Putri, 2023). However, their effectiveness depends on the availability of adequate facilities and the competence of teachers. In addition, collaboration with industry is a key factor in maintaining the relevance of learning through continuous updates in technology and competency standards (Asian Development Bank, 2021).

Based on the literature review, vocational education still faces competency gaps influenced by the rapid development of technology and the limitations in implementing industry-based learning. Industrial internships (PKL) play a strategic role in identifying these gaps through students' direct experiences, while project-based and simulation-based instructional design has the potential to improve learning relevance. However, previous studies have generally not integrated quantitative GAP analysis with qualitative reflections from internship experiences as a basis for developing instructional design. Therefore, this study addresses this gap by employing a mixed methods approach to generate more adaptive and industry-oriented learning recommendations.

3. Research Method and Materials

This study employed a mixed methods approach with an explanatory sequential design. According to Sugiyono (2022), this method integrates quantitative and qualitative approaches to produce more comprehensive, valid, and reliable data. This approach was selected because it enables a deeper explanation of data integration at the interpretation stage, particularly in identifying competency needs for the development of technology-based instructional design. Data were collected using a Google Forms questionnaire, which is considered efficient for digital learning research (Putra, 2022).

The research instrument was developed based on a literature review related to TKJ competencies and the needs of the information technology industry, covering the relevance of practical materials, the utilization of instructional technology, and work readiness based on industrial internship (Praktik Kerja Lapangan/PKL) experience. The indicators referred to previous studies on vocational competency gaps and industry needs (Hidayat et al., 2022; Prasetyo & Kusumawardani, 2023), as well as vocational school revitalization policies that emphasize alignment between education and industry.

To ensure the suitability of the indicators with the measured constructs, the instrument was reviewed qualitatively through expert judgment involving two TKJ vocational teachers and one computer networking industry practitioner with experience in supervising PKL. The evaluation focused on the alignment of items with competency indicators, clarity of wording, relevance to industry needs, and representation of competency dimensions. The review results were used to make minor revisions to improve clarity and operationalization. Overall, all items were considered to adequately represent the measured constructs and were deemed appropriate for use as research instruments.

Furthermore, the reliability of the instrument was tested to ensure the internal consistency of the items (Ghozali, 2018). The instrument was considered reliable if the Alpha value was ≥ 0.70. The Cronbach's Alpha test conducted on the Likert-scale items (p1–p10) resulted in a value of 0.864, which falls into the category of good reliability ($\alpha \geq 0.80$), indicating that the instrument is consistent and suitable for use in this study.

The instrument used a Likert scale ranging from 1 to 5 to assess students' perceptions of the relevance of school learning to industry needs, as well as open-ended questions to explore new competencies acquired during PKL. The instrument consisted of 10 indicators grouped into three main dimensions related to internship readiness and instructional technology design.

Table 1. Distribution of Statement Dimensions

Statement Code	Dimension	Number of Items
p1–p4	Relevance of Learning Materials & Technology	4
p5–p9	Effectiveness of Learning Media and Technology	5
p10	Reflection & Learning Design Needs	1
p11–p12	Open-Ended Questions	2

The research sample was determined using a purposive sampling technique, which involves selecting respondents based on specific criteria aligned with the research objectives (Darmadi, 2014). The criteria included twelfth -grade Computer and Network Engineering (TKJ) students who had completed a three-month industrial internship (Praktik Kerja Lapangan/PKL) from August to October 2025, as they possessed direct experience in assessing the relevance of learning and technological needs (Ilyas & Suryani, 2022). Based on these criteria, a total of 31 respondents were selected. Quantitative data were analyzed using descriptive statistics through the calculation of the mean value with the following formula:

$$\bar{X} = \frac{\sum X}{N}$$

Where:
X= mean value,
$\sum X$= total score of all respondents,
N= number of respondents.

Descriptive statistics in the form of mean values were used to describe the tendency of participants' responses on the Likert scale quantitatively (Joshi et al., 2022; Sullivan & Artino, 2023). The mean values were then interpreted into categories of students' perception levels to identify competency gaps based on the applied guidelines (Winata & Handayani, 2022):

Table 2. Scale of Perceived Competency GAP Levels

Mean Score Range	Category
4.21 – 5.00	Very Good
3.41 – 4.20	Good
2.61 – 3.40	Fair
1.81 – 2.60	Poor
1.00 – 1.80	Very Poor

In addition to descriptive analysis, this study employed GAP analysis to identify discrepancies between learning conditions in schools and industry demands. This analysis measures the difference between actual and ideal conditions as a basis for evaluation and for determining priorities in improving learning processes. The GAP approach is considered effective in mapping the level of competency gaps and identifying aspects that require systematic intervention (Tarigan & Sinaga, 2021), as well as aligning with quality evaluation standards (Sujarweni, 2014). The larger the GAP value, the higher the priority for developing instructional technology design in that aspect. The GAP formula is as follows:

$$GAP = S_i - \bar{X}$$

GAP= GAP value,
S_i= ideal score (5)
$\bar{X}$ = mean value.

Table 3. GAP Value Interpretation Scale

Mean Score Range	Category	Interpretation
≥ 2,00	High GAP	High discrepancy, becomes the main priority for development
1.00 – 1.99	Moderate GAP	Moderate discrepancy, requires gradual improvement
0.00 – 0.99	Low GAP	Low discrepancy, condition relatively close to the ideal standard

The interpretation of GAP values is based on a Likert scale of 1 −5 with a theoretical range of 4 (5−1), which is divided into three categories of gaps. GAP values of 0.00 −0.99 are categorized as low gaps, 1.00−1.99 as moderate gaps, and ≥2.00 as high gaps. This classification is used to provide a systematic interpretation of the differences between actual and ideal conditions.

The ideal score is set at 5; therefore, a higher GAP value indicates a greater competency gap and a higher priority for instructional development. GAP analysis provides an overview of aspects that are not yet optimal, serving as a basis for designing more adaptive and industry-relevant learning. Qualitative data obtained from open-ended questions were analyzed using thematic analysis through stages of data reduction, open coding, categorization, and identification of main themes to determine learning needs based on internship (PKL) experiences (Sari & Mulyani, 2023).

4. Results and Discussion

4.1. Research Results

This study produced an analysis of competency gaps among Computer and Network Engineering (TKJ) students as a basis for developing instructional technology design, with a focus on the alignment of learning materials, media, and learning experiences with industry needs. The analysis was conducted across three main dimensions: the relevance of learning materials and instructional technology, the effectiveness of media in supporting competency mastery, and reflections on internship (PKL) experiences as a basis for improving learning. Through descriptive analysis, GAP analysis, and qualitative data from 31 respondents, the study provides an overview of learning aspects that are already effective, as well as areas that still require improvement to better align with industry demands.

4.1.1 Quantitative Analysis

a. Relevance of Learning Materials and Technology (p1 –p4)

This dimension assesses the alignment of practical materials, the suitability of instructional technology, and their relevance to industry needs.

Table 4. Interpretation of the Relevance of Learning Materials and Technology

Code	Statement	Mean	Category
p1	Practical materials prepare students for PKL tasks	4.32	Very Good
p2	Ability to operate industrial networking devices	3.94	Good
p3	Troubleshooting aligned with industry practices	3.55	Good
p4	School tools/equipment are similar to those used in industry	3.71	Good

The results of the analysis on the dimension of the relevance of learning materials and instructional technology indicate that students perceive practical materials in school as highly supportive of their readiness for industrial internships (PKL), as reflected by the highest score on p1 (4.32). The ability to operate networking devices (p2) and troubleshooting skills (p3) are categorized as good, although they still require improvement to better align with industry standards. The alignment between school tools or equipment and those used in industry (p4) is also rated as good, indicating that school facilities are relatively relevant to workplace demands.

b. Effectiveness of Learning Technology (p5–p9)

Table 5. Interpretation of the Effectiveness of Learning Technology

Code	Statement	Mean	Category
p5	Teachers discuss the latest technologies	3.52	Good
p6	Ready to work after completing PKL	4.29	Very Good
p7	Subjects and learning media are relevant to industry	3.87	Good
p8	Learning needs to be updated	3.74	Good
p9	Learning technology supports competency development	4.00	Good

In the dimension of learning media and technology effectiveness, students perceive that the learning provided has been sufficiently effective in enhancing their competencies. The highest score is found in p6 (4.29), indicating that PKL experiences greatly support students' work readiness. Other indicators, such as the discussion of the latest technologies (p5), the relevance of subjects and learning media (p7), and the need for updating learning (p8), fall within the good category. These findings suggest that learning is already effective; however, continuous innovation is still required to keep pace with technological developments. The learning technologies used (p9) are also considered to adequately support students' competencies.

c. PKL Reflection and Learning Design Needs (p10)

Table 6. Interpretation of PKL Reflection and Learning Design Needs

Code	Statement	Mean	Category
p10	PKL highlights the differences between school and industry technologies	4.19	Good

In the dimension of internship (PKL) reflection and instructional design needs, students provided a positive evaluation (mean = 4.19) of their PKL experience, which broadened their understanding of the technological differences between school and industry. These findings indicate that PKL plays a crucial role in helping students recognize existing competency and technological gaps, while also highlighting the need to develop more adaptive instructional designs aligned with industry demands to ensure that students' competencies remain relevant to workplace requirements.

d. GAP Analysis

The analysis results indicate that all indicators still show a discrepancy from the ideal score, with varying levels of GAPs ranging from low to high categories.

Table 7. Interpretation of Competency GAP between TKJ and Industry

Item Code	Mean	GAP (5 – Mean)	GAP Category	Interpretation
p1	4.32	0.68	Low	Practical materials are relatively aligned with industry needs
p2	3.94	1.06	Moderate	Improvement is needed in mastering industrial devices
p3	3.55	1.45	Moderate	Troubleshooting is not yet fully aligned with industry standards
p4	3.71	1.29	Moderate	School equipment requires better alignment with industry
p5	3.52	1.48	Moderate	Discussion of the latest technologies needs to be strengthened
p6	4.29	0.71	Low	PKL supports students' work readiness
p7	3.87	1.29	Moderate	The relevance of subjects and learning media needs optimization
p8	3.74	1.26	Moderate	Learning needs to be updated in line with technological developments
p9	4.00	1.00	Moderate	Learning technology sufficiently supports competencies but is not yet optimal
p10	4.19	0.81	Low	PKL helps raise awareness of differences between school and industry technologies

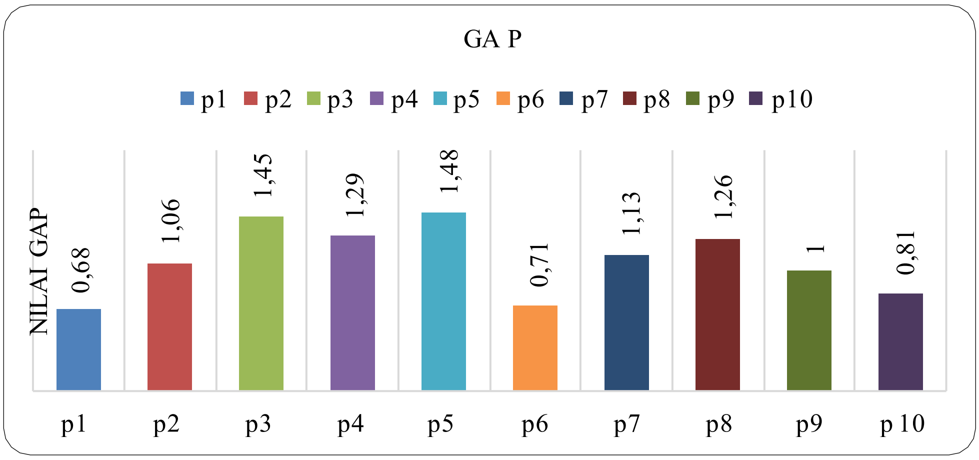

Figure 1. Graph of Competency GAP Analysis between TKJ and Industry

Based on the GAP interpretation criteria, most indicators fall into the moderate gap category, indicating the need for gradual improvement in the development of instructional technology design. The highest gaps are found in the indicators related to the discussion of the latest technologies (1.48) and troubleshooting based on industry standards (1.45), suggesting that technological updating and industry -based practice should be prioritized. Meanwhile, indicators such as the readiness of practical materials (0.68), job readiness after PKL (0.71), and PKL reflection (0.81) fall into the low gap category, indicating that the foundational aspects of learning are relatively strong. The graph in Figure 1 illustrates that the distribution of gaps across indicators is relatively even within the moderate category, with p5 and p3 identified as the main priorities for improvement.

4.1.2 Qualitative Analysis

Qualitative data were obtained from two open-ended questions answered by 31 respondents. Although the number of open-ended items was limited, the responses showed consistent and recurring patterns, allowing for categorization and theme identification. Qualitative analysis of the responses to items p11 and p12 resulted in five main themes that represent students' perceptions of the gap between TKJ learning in schools and industry needs. The results of the analysis are as follows:

Table 8. Results of Qualitative Analysis of Competency GAPs between TKJ and Industry

No	Theme	Description of Findings	Implications for Learning Design
1	Limited Integration of Industrial Technology in the Curriculum	Respondents mentioned several industrial technologies that have not been optimally taught in schools, such as fiber optics (ONT, termination), industrial software (Nmap, Exam Browser, Zoom, advanced Office, scanning tools), advanced system installation (BIOS/UEFI), servers and network security, as well as AI.	The curriculum and learning technology design need to be updated to be more adaptive to the latest developments in industrial technology.
2	Insufficient Depth of Contextual Technical Practice	Practical activities in schools are still limited to basic tasks such as device assembly, system updates, application installation, simple troubleshooting, and limited LAN configuration.	Practical learning needs to be developed based on real cases and industry simulations to reflect the complexity of technical work.

No	Theme	Description of Findings	Implications for Learning Design
3	Limitations in LearningFacilities and Infrastructure	Students highlighted the lack of fiber optic equipment, industry-standard networking tools, and limited devices for practice simulation.	It is necessary to improve and update TKJ laboratory facilities to align with industry standards.
4	Need for Intensive Practice-Based Learning	Students stated that learning would be more effective with increased hands-on practice and collaboration with industry.	Learning design should adopt a learning-by-doing approach, project-based learning, and enhanced industry collaboration.
5	Strengthening Non-Technical Competencies (Soft Skills)	Respondents emphasized the importance of communication, teamwork, and problem-solving as part of work readiness.	Learning should integrate soft skills development through collaborative activities and problem-based learning.

4.1.3 Integration of Quantitative and Qualitative Results

The results of the quantitative analysis indicate that the highest gaps occur in the discussion of the latest technologies and in troubleshooting practices based on industry standards, while the readiness of practical materials and internship (PKL) experiences show relatively low gaps. These findings are further elaborated through qualitative analysis to explain the underlying factors.

The qualitative analysis identified five main themes. The theme of limited integration of industrial technologies in the curriculum explains the high GAP in the discussion of the latest technologies, as indicated by the absence of instruction on technologies such as fiber optics, industrial software, network security, and artificial intelligence. In addition, the theme of insufficient contextual depth in technical practice clarifies the gap in troubleshooting indicators, where learning practices remain basic and are not yet based on real industrial cases.

The theme of limited facilities and infrastructure also aligns with the gap in the suitability of school equipment with industry standards (GAP 1.29), indicating that the gap is not only related to learning materials but also to facilit ies. Meanwhile, the themes of the need for intensive practice-based learning and the strengthening of non-technical competencies indicate that students expect a greater emphasis on practical activities as well as the development of soft skills such as communication, teamwork, and problem -solving.

The integration of these quantitative and qualitative findings demonstrates that competency gaps are not only conceptual in nature but are also influenced by the implementation of learning and real conditions in practice, as summarized in the following table.

Table 9. Integrated Analysis of Quantitative and Qualitative Results

Item Code	Quantitative Indicator	GAP Value	Supporting Qualitative Theme	Integrative Meaning
p5	Teachers discuss the latest technologies	1.48	Limited Integration of Industrial Technology	Learning has not fully accommodated the latest developments in industrial technology
p3	Troubleshooting aligned with industry standards	1.45	Insufficient Depth of ContextualTechnical Practice	Practices are not yet based on real cases and industry standards
p4	Alignment of school equipment with industry	1.29	Limitations in Facilities and Infrastructure	Laboratory facilities need improvement to meet industry standards
p8	Learning needs to be updated	1.26	Need for Intensive Practice-Based Learning	Innovation and updates in practice-based learning design are required

Item Code	Quantitative Indicator	GAP Value	Supporting Qualitative Theme	Integrative Meaning
p7	Relevance of subjects and learning media to industry	1.29	Intensive Practice & Soft Skills	Material relevance is fairly good but requires contextual and collaborative strengthening
p1	Practical materials prepare students for PKL	0.68	—	The learning foundation is relatively aligned with industry needs
p6	Ready to work after PKL	0.71	—	PKL experience effectively improves work readiness
p10	PKL reflection on technologicaldifferences	0.81	Awareness of Technology GAP	PKL helps students understand differences between school and industry standards

42. Discussion

42.1. Interpretation of TKJ Students' Competency GAPs in Relation to Industry Needs

The findings of this study indicate that, in general, TKJ learning has provided a strong foundation of competencies, particularly in preparing students for industrial internships (PKL). This is reflected in the high mean scores for indicators of practical material readiness (4.32) and job readiness after PKL (4.29), both of which fall into the low gap category. These results suggest that the learning process has been able to equip students with basic competencies relevant to industry needs.

Internship (PKL) experiences play a significant role in strengthening work readiness through contextual learning that connects theory with industrial practice. This is consistent with Lestari and Pratama (2022), who state that PKL functions as a reflective medium in reducing the gap between academic competencies and professional demands. Through direct experience, students not only apply technical skills but also evaluate the alignment of their competencies with industry standards.

However, TKJ learning has not yet fully eliminated competency gaps, particularly in the integration of up-to-date industrial technologies and troubleshooting practices based on real-world conditions. This indicates a gap between the rapid development of industrial technologies and the updating of learning processes in schools. Although the foundation of basic competencies has been established, the depth of practice and adaptation to emerging technologies still require further strengthening.

These findings are in line with Rahmawati and Nugroho (2023), who emphasize that delays in updating learning materials and adapting to technological advancements are key factors contributing to competency gaps in the field of information technology. Therefore, the main challenge in TKJ learning lies in the ability of the educational system to rapidly adapt to the dynamics of industrial technology and to provide practical experiences that align with actual workplace standards.

42.2. The Role of PKL as a Reflection and Reinforcement of Competency GAP Identification

The results of the qualitative analysis reinforce the quantitative findings regarding competency gaps. Students identified limitations in the integration of industrial technologies into learning, such as fiber optics, industrial software, network security, and artificial intelligence. In addition, learning practices are still perceived as procedural and not yet based on real industrial cases. These findings are consistent with Prasetyo and Kusumawardani (2023), who state that gaps in the field of computer networking mainly occur in contextual troubleshooting skills and the mastery of professional tools. This indicates that the results of the GAP analysis reflect students' actual experiences during PKL rather than merely general perceptions.

In this context, PKL functions not only as a work experience but also as a reflective instrument for evaluating the relevance of learning. Students' perceptions after completing PKL can serve as a basis for improving instructional design to better align with actual industry practices.

4.2.3. Supporting and Inhibiting Factors of Learning Relevance

In addition to material and practical aspects, students also highlighted limitations in laboratory facilities and infrastructure, such as fiber optic equipment, industry-standard networking tools, and simulation facilities for practical activities. This indicates that the relevance of learning is not only determined by the curriculum but also by the alignment of facilities with industry needs. These findings are consistent with the Asian Development Bank (2021), which emphasizes that the effectiveness of vocational education is influenced by infrastructure support and industry collaboration. Without adequate facilities, technology-based learning cannot reflect the complexity of real-world work practices, thereby potentially widening students' competency gaps.

Overall, the findings of this study confirm that the main challenges in TKJ learning lie in technological updating, the deepening of practice based on real-case scenarios, and the integration of non-technical competencies. Therefore, more adaptive instructional technology design is required to respond to the dynamics of the digital industry.

4.2.4. Implications for Learning Technology Design in the TKJ Program

Based on the analysis and interpretation of the research findings, the development of learning technology design in the TKJ program not only requires alignment with academic needs but must also be responsive to the continuously evolving dynamics of industry. Therefore, several fundamental perspectives are needed as a foundation for designing learning that is relevant, contextual, and sustainable. These perspectives are formulated as follows:

Table 10. Fundamental Perspectives in the Development of Learning Technology Design in the TKJ Program

No	Perspective	Description
1	Adaptive Learning to Industrial Technological Developments	Learning design needs to systematically and continuously integrate developments in industrial technology through mechanisms for updating learning materials and synchronizing them with industry needs.
2	Strengthening Industry Case-Based Practice	Learning should be directed toward case-based approaches and real industry simulations. The integration of problem-based learning and project-based learning becomes a key strategy in enhancing contextual troubleshooting skills and system analysis capabilities.
3	Optimization of Representative Practice Environments	TKJ laboratories need to be developed as practice environments that represent industry standards to create more authentic learning experiences.
4	Integration of Technical and Non-Technical Competencies	The development of soft skills such as communication, teamwork, and problem-solving should be integrated into project-based and collaborative learning activities.
5	PKL as a Continuous Feedback Mechanism	Students' reflections after PKL should be utilized as a basis for continuous evaluation and improvement of learning design.

4.2.5. Limitations

This study has several limitations. First, the number of respondents was limited to a single school, so the generalization of the findings should be approached with caution, considering differences in facilities, curricula, and industry partnerships across schools. Second, the data were primarily based on students' post-internship (PKL) perceptions, and therefore may not fully represent objective assessments from industry regarding student performance. Third, this study did not incorporate performance measurements based on industry standards, such as external competency tests or evaluations from industry supervisors. Consequently, the results of the GAP analysis tend to reflect perceived gaps rather than standardized performance outcomes.

Future research is recommended to involve multiple institutions, integrate industry-based assessments, and utilize instruments based on competency standards in order to obtain a more comprehensive and objective understanding of competency gaps.

5. Conclusion

The findings of this study confirm that TKJ learning has provided a relevant foundation of basic competencies, particularly in preparing students for Industrial Work Practice (PKL) and building initial work readiness. PKL experience has proven to play a significant role as a medium for contextual learning as well as a reflective mechanism in identifying GAPs between school-based learning and actual industrial practices.

However, the analysis results indicate that competency GAPs still exist, particularly in the integration of the latest industrial technologies and the deepening of troubleshooting practices based on industry standards. These GAPs are not solely related to the updating of learning materials, but also to the limitations of real case-based practice, laboratory facility support, and the integration of non-technical competencies in the learning process. These findings emphasize that the main challenge in TKJ education does not lie in mastering basic competencies, but in the ability of the learning system to adapt rapidly to the dynamics of industrial technology and to provide authentic and contextual learning experiences aligned with real workplace practices.

From a theoretical perspective, this study contributes by integrating quantitative GAP analysis with qualitative reflections on PKL experiences as a basis for formulating learning technology design. The mixed methods approach employed enables a more comprehensive and empirically grounded mapping of competency GAPs. From a practical perspective, the findings recommend the development of learning design that is adaptive to industrial technological advancements, the strengthening of case-based and industry simulation practices, the optimization of representative laboratory environments, the integration of technical and non-technical competencies, and the utilization of PKL reflection as a continuous feedback mechanism for improving curriculum and learning processes. Thus, this study highlights the importance of reconstructing TKJ learning technology design to be more contextual, adaptive, and collaborative with industry in order to minimize competency GAPs and enhance the relevance of graduates to the demands of the digital workforce.

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