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Internet Integration Improves 4C Competencies and Basic Automotive Learning Achievement with SKKNI Standards Through Classroom Action Research

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Abstract: *Vocational education demands graduates who master technical competencies according to industry standards alongside 21st-century global skills. However, conventional learning that fails to optimize digital literacy often leaves students passive and yields low performance in work safety materials. This study aims to analyze the role of internet integration in improving the 4Cs global competence and SKKNI-based learning achievement of vocational students in Automotive Basic Work. This research employed a Classroom Action Research design conducted across three stages: pre-cycle, cycle I, and cycle II. The subjects comprised 35 class X TKRO students at SMK Ma'arif NU Doro, selected via purposive sampling. Data were collected through performance observations, assessments, and teacher evaluations, then analyzed using percentage techniques against an 85% classical completeness indicator. The results demonstrated a significant increase in average 4C competency from 30% to 90%, while SKKNI learning completeness rose from 20% to 86% by cycle II. Structured internet integration effectively transforms gadgets into productive learning instruments that simultaneously strengthen 21st-century skills and industrial work competency standards. These findings offer a practical pedagogical model for vocational teachers to align digital learning with the demands of graduate job readiness in the modern industrial world.*

Keywords: *Vocational Education, 4C Competencies, SKKNI, Classroom Action Research, Digital Literacy*

Introduction

21st-century education requires graduates to master not only technical skills but also global competencies known as the 4Cs: Critical Thinking, Collaboration, Communication, and Creativity. These competencies, combined with technical proficiency aligned with SKKNI standards, form the foundation for vocational graduates' readiness in meeting industry requirements (Saniuk et al., 2022; Gajdzik & Wolniak, 2022). A study supports this view Abina et al. (2022) and Tyson & Zysman (2022), highlighting that the 4Cs form a vital foundation for modern workers to adapt to technological advancements and global industry demands. In vocational education, integrating 4C skills is increasingly important, as graduates are expected to be procedurally prepared while also demonstrating critical thinking, effective collaboration, clear communication, and innovative problem-solving abilities in their fields (Loyens et al., 2023; Laura I. G. Perez &

Maria S. R. Montoya, 2022). However, many Indonesian vocational schools still rely heavily on conventional teacher-centered approaches, which limit opportunities for students to develop these global competencies (Sukackė et al., 2022; Amadi, 2023). According to Daniela (2021) and Wang (2022), this condition is worsened by the underutilization of digital technology as a productive learning tool, despite the fact that today's students are digital natives accustomed to using gadgets and the internet. Consequently, a learning strategy is necessary to bridge the gap between students' technological capabilities and the requirements of 21st-century competencies they need to acquire. When effectively managed with appropriate pedagogy, the internet can facilitate the internalization of 4C skills critical thinking, communication, collaboration, and creativity through global information access, online collaboration, and opportunities for digital exploration.

In the context of vocational education in Indonesia, the Indonesian National Work Competency Standard (SKKNI) serves as the primary reference to ensure that graduates from vocational schools possess industry-recognized qualifications (Geven & Spörlein, 2023); (Walidayni et al., 2023). Furthermore, according to Hassan et al. (2021) and Peng et al. (2023), integrating information technology is essential for developing vocational graduates who can adapt to industry dynamics. This includes mastering SKKNI-based Occupational Safety and Health (K3) material (G.45OTO01.001.2) within the Automotive Basic Work curriculum.

However, initial observations at SMK Ma'arif NU Doro Pekalongan reveal that K3 learning based on SKKNI (G.45OTO01.001.2) is still conducted conventionally, relying on textbooks and whiteboards as the primary teaching tools. Consequently, students tend to be passive and are not actively engaged in exploring digital information. As a result, the competency achievement of SKKNI students remains low, with only 20% deemed competent during the pre-cycle stage. Their understanding of occupational safety procedures often lacks practical application, relying instead on rote memorization.

Additionally, the gadgets owned by students frequently serve as distractions rather than tools for knowledge acquisition, largely due to the absence of systematic guidance from teachers on effectively utilizing the internet for learning. This situation, as indicated by Ng et al. (2023) and (Bacalja et al. (2022), highlights the disparity between the potential of available technology and the current pedagogical practices, which have yet to optimally integrate digital literacy into vocational education.

The disparity between theory and practice is evident in literature highlighting the role of ICT in education. Rötkönen et al. (2022) and Benita et al. (2021) contend that information and communication technologies can transform learning interactions from physical environments to virtual ones, enabling students to collaborate within a digital ecosystem similar to modern workplaces. However, on-the-ground implementation reveals that teachers struggle to facilitate this transition due to limited digital pedagogical skills and the absence of digital literacy guidelines tailored to materials like SKKNI-based K3 (G.45OTO01.001.2). Wohlfart & Wagner (2023) and (Peng et al. (2023) further

emphasize that teachers can foster holistic learning through effective technology integration, yet pre-cycle findings indicate that their performance with internet media remains low, at just 60%. This creates a disconnect between the theoretical framework advocating technology integration and the actual capabilities of teachers and students in real classroom settings. Addressing this gap necessitates action research interventions that not only evaluate the effectiveness of internet-based strategies but also enhance teachers' abilities to manage digital learning focused on developing the 4Cs and SKKNI.

This research is significant as it tackles a key challenge in vocational schools: transforming gadgets, often seen as distractions, into effective tools for knowledge production. Pham et al. (2021) and Cavanagh & Kiersch (2023) underscore the necessity for micro-practical solutions to adapt to the demands of 21st-century education. This study presents a concrete model through the integration of guided internet resources in SKKNI-based K3 learning (G.45OTO01.001.2). Furthermore, Tani et al. (2022) and Hefter (2023), highlight that the quality of learning media directly impacts learning outcomes, suggesting that structured internet-based interventions can significantly enhance the achievement of SKKNI competencies. Therefore, this research not only advances vocational pedagogy but also provides empirical evidence that digital literacy can serve as a crucial factor in strengthening the relationship between 21st-century competencies (the 4Cs) and work competency standards.

This study aims to analyze the role of the internet in enhancing the global competency of the 4Cs and SKKNI competencies among class X students at SMK Ma'arif NU Doro, both individually and collectively. The research is closely linked to existing literature, as it examines and expands upon the findings in Abina et al. (2022) and Tyson & Zysman (2022), within the context of vocational education in Indonesia.

Accordingly, to address the identified gaps, this study is guided by the following specific research questions:

1. RQ1: How does structured internet integration individually impact the improvement of students' 4C global competencies and their SKKNI-based learning achievements in basic automotive work?
2. RQ2: What is the simultaneous effect of internet integration on fostering both 4C soft skills and SKKNI-aligned hard skills within the vocational classroom?
3. RQ3: What pedagogical mechanisms drive these significant improvements, and how do they contribute to the broader advancement of digital learning models in vocational education?

Methodology

This study employs a Classroom Action Research (PTK) design based on a cyclical model comprising four key stages: planning, implementation, observation, and reflection. The research was conducted in three phases: pre-cycle, cycle I, and cycle II, to track the progressive improvement of student competence. Each cycle consists of three meetings, totaling 9 sessions of 45 minutes each, which facilitates thorough observation of the

internet-based learning process. This approach was selected for its effectiveness in enhancing collaborative learning practices between researchers and partner teachers within a natural classroom environment.

The research was conducted at SMK Ma'arif NU Doro Pekalongan, involving 35 class X students from the Automotive Light Vehicle Engineering (TKRO) program, which included 34 males and 1 female. Participants were selected using a purposive sampling technique, as the class was engaged in K3 material based on SKKNI (G.45OTO01.001.2) within the Automotive Basic Work subject. The study is scheduled to take place over three months September, October, and November 2025 to maintain consistency in the intervention and measurement of its impact. The cyclical design of the research allows for continuous improvements based on reflections at each stage, ensuring that interventions are more effectively targeted.

The research instrument was created using digital literacy indicators, 4C global competencies, SKKNI standards, and teacher performance, all validated through expert judgment. Data collection involved participatory observation, assessments of student performance, documentation of learning activities, and teacher evaluation sheets completed by independent observers.

The data collection procedure commenced with a pre-test during the pre-cycle to establish the initial condition. This was followed by an internet-based intervention in cycles I and II, which included intensive support. Quantitative data were analyzed using percentage techniques to evaluate the achievement of each indicator, categorized into value intervals: very low (<40%), low (40-55%), adequate (56-70%), good (71-85%), and very high (>85%). A classical completeness threshold was set, requiring a minimum of 85% of students to reach the competent category as a marker of research success. The analysis also involved cross-cycle comparisons to identify trends in improvement and the effectiveness of the interventions. The entire analysis process is conducted systematically to ensure that the research results can be replicated by other researchers in similar vocational education contexts.

Result and Discussion

Table 1 summarizes the achievements of students in the 4C (Critical Thinking, Collaboration, Communication, Creativity) global competencies across each research cycle. The data is presented as percentages and categorized by each competency dimension, facilitating the identification of improvement trends following the implementation of internet-based learning strategies.

Table 1. Recapitulation of the 4C Global Competencies in Each Cycle

4C Competency Dimension	Indicator	Pre-Cycle	Cycle I	Cycle II	Criteria for Completeness
Critical Thinking	Able to analyze potential hazards, compare SOPs, and solve K3 problems (G.45OTO01.001.2) using valid data from the internet	30%	60%	90%	≥ 85%

Collaboration	Able to work together in teams, share digital tasks, and divide professional roles to complete projects	35%	65%	95%	≥ 85%
Communication	Able to present K3 procedures (G.45OTO01.001.2), present digital findings, and convey systematic narratives in front of the class	30%	60%	85%	≥ 85%
Creativity	Able to generate new ideas/works, draft posters, and create innovative K3 educational content (G.45OTO01.001.2)	25%	55%	90%	≥ 85%
Average Achievement 4C	The overall percentage of global competency dimensions measured	30%	60%	90%	≥ 85%
Reach Categories	Qualitative description based on percentage intervals	Low - Very Low	Enough - Good	Very High	-
Differences with Criteria	Comparison of average achievement to minimum standard of 85%	-55%	-25%	+5%	-
Upward Trend	Average percentage change between cycles	-	+30%	+30%	-
Highest Achievement Indicators	The 4C dimension that gets the maximum percentage in each cycle	Collaboration (35%)	Collaboration (65%)	Collaboration (95%)	-
Lowest Achievement Indicators	The 4C dimension that gets the minimum percentage in each cycle	Creativity (25%)	Creativity (55%)	Communication (85%)	-
Consistency of Improvement	Pattern of development of competency achievement from pre-cycle to cycle II	Beginning	Increase	Optimal	-
The Impact of Internet Intervention	The level of influence of internet-based learning strategies on strengthening the 4Cs	Minimal	Signifikan	Very Significant	-
Evaluative Conclusions	Summary of the status of the 4C's global competencies based on quantitative data	30% < 85%: Need for Intervention	60% < 85%: Need Improvement	90% > 85%: Successfully Completed	

The 4C global competency data from the pre-cycle stage indicates that achievements across all measured indicators remain low. Critical thinking scored 30% in the low category, while collaboration was slightly higher at 35%, also in the low category. The communication indicator recorded a 30% achievement, and creativity scored the lowest at 25%, falling into the very low category. Overall, the average achievement for 4C competencies in the pre-cycle was 30%, highlighting the need for targeted learning interventions.

In Cycle I, the implementation of internet-based learning strategies led to significant improvements across all 4C competencies. Critical thinking increased to 60% in the sufficient category, collaboration rose to 65% in the good category, communication improved to 60% in the adequate category, and creativity reached 55%, also in the adequate category. The average achievement for 4C competencies in Cycle I was 60%, indicating a positive trend, although it did not yet meet the success indicators.

By Cycle II, all 4C competency indicators experienced a remarkable increase, moving into the very high category. Critical thinking achieved 90%, collaboration reached 95%, communication hit 85%, and creativity scored 90%. The average achievement for 4C competencies in Cycle II rose to 90%, surpassing the classical completeness criteria established for this study.

Pre-cycle data indicated that the achievement of SKKNI K3 material (G.45OTO01.001.2) was notably low, with hazard recognition skills at 30%, PPE compliance at 20%, safe work procedures at 25%, and waste handling at 30%. Only 20% of students (7 students) demonstrated competency. In Cycle I, the integration of internet resources led to improvements across all indicators: hazard recognition rose to 70%, PPE compliance to 60%, safe work procedures to 65%, and waste handling to 60%, resulting in an overall learning completeness of 57% (20 competent students). By Cycle II, the achievements of SKKNI showed very satisfactory results, with both hazard recognition and safe work procedures reaching 90%, while PPE compliance and waste handling reached 85%. Learning completeness improved to 86% (30 competent students), surpassing the success indicator of ≥85%, thus declaring the research successful.

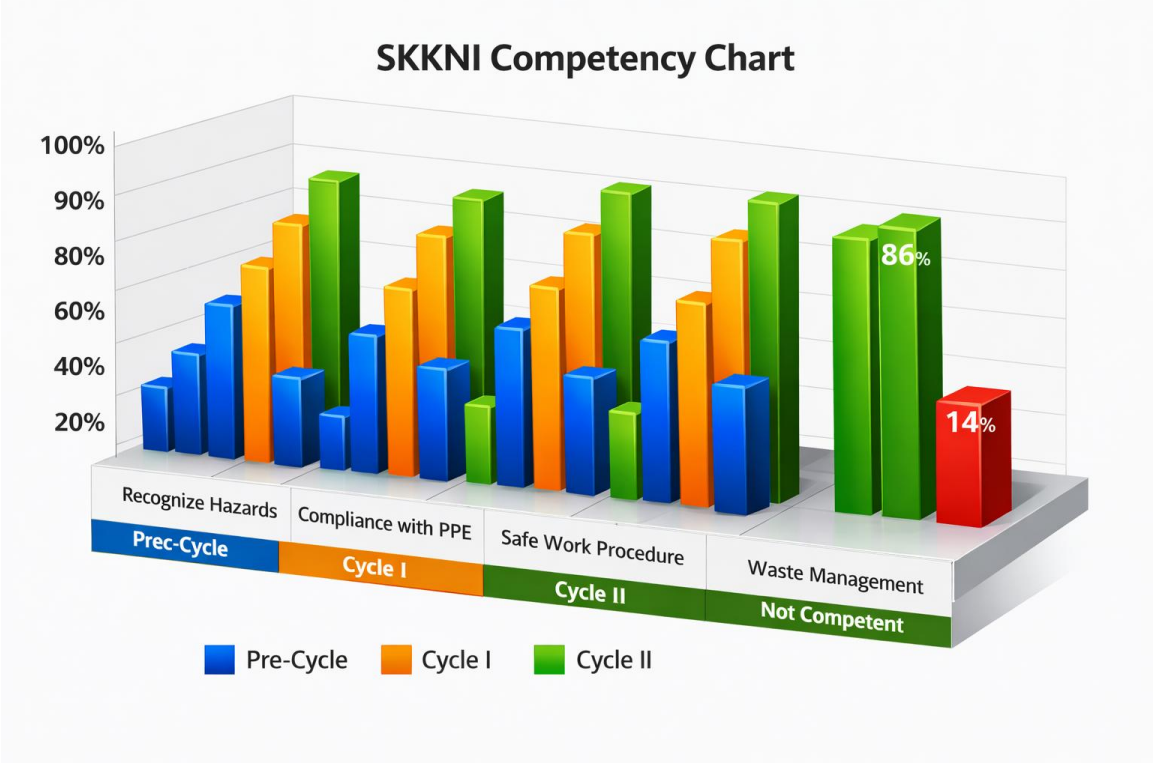

Figure 1. SKKNI Competency Achievement Chart

The table 2 below summarizes teacher performance in each research cycle, evaluated through three key aspects: the initial activity, the core activity, and the final learning activity. The data is presented as achievement percentages, illustrating the progress teachers have made in managing internet-based learning, facilitating students' 4C competencies, and integrating digital literacy into SKKNI-based K3 materials (G.45OTO01.001.2).

Table 2 Recapitulation of Teacher Performance in Each Cycle

Assessment Aspects	Activity Indicators	Pre-Cycle	Cycle I	Cycle II	Success Criteria
Early Activities	Checking student readiness and conducting appendicitis	5%	8%	8,3%	-
Core Activities	Material mastery, learning approach, media utilization, process assessment, language use	51%	60%	83,4%	-
Final Activities	Reflections, summaries, and follow-up of learning	4%	7%	8,3%	-
Total Teacher Performance Score	Overall percentage of observed aspects	60%	75%	100%	≥ 80%
Differences with Criteria	Comparison of achievement to minimum standards of 80%	-20%	-5%	+20%	-
Upward Trend	Percentage change between cycles	-	+15%	+25%	-
Aspects with the Highest Improvement	The components that experienced the most significant spikes in achievement	-	Core Activities (+9%)	Core Activities (+23,4%)	-
Consistency of Improvement	Performance development pattern from pre-cycle to cycle II	Awal	Meningkat	Optimal	-
Digital Technology Integration	The level of use of the internet as a learning medium	Minimal	Structured	Optimal	-
Fasilitasi Kompetensi 4C	Teacher support for the development of Critical Thinking, Collaboration, Communication, Creativity	Low	Enough	Very High	-
Evaluative Conclusions	Summary of teacher performance status based on quantitative data	60% < 80%: Not Successful	75% < 80%: Not Successful	100% > 80%: Succeed Perfect	-

Teacher performance data from the pre-cycle stage indicates that improvements are needed across all observed learning activities. The initial activity scored 5%, the core activity scored 51%, and the final activity scored 4%, resulting in an overall teacher performance score of 60%. This score falls short of the success criterion of 80%, leading to the conclusion that teacher performance in the pre-cycle was unsuccessful.

In the first cycle, teacher performance improved in all aspects of learning activities following the implementation of a more structured internet-based learning strategy. The initial activity increased to 8%, the core activity rose to 60%, and the final activity reached

7%, resulting in an overall score of 75%. While this represents progress compared to the pre-cycle, the 75% score still does not meet the minimum success indicator of 80%, categorizing teacher performance in the first cycle as unsuccessful.

In cycle II, teacher performance demonstrated significant improvement, achieving maximum scores across all measured aspects. The initial activity reached 8.3%, the core activity achieved 83.4%, and the final activity scored 8.3%, resulting in a total overall score of 100%. This achievement exceeds the minimum success criteria of 80%, declaring teacher performance in cycle II as perfectly successful. The improvement from pre-cycle to cycle II reflects consistent progress in learning management, the integration of digital technology, and the facilitation of students' 4C competencies.

In the Pre-Cycle stage, all four 4C competency dimensions fell within the low to very low range, with achievement levels between 25% and 35%. Creativity recorded the lowest percentage at 25%, while collaboration reached 35%. Following the implementation of an internet-based learning strategy in Cycle I, there was a notable improvement across all dimensions, with achievements rising to between 55% and 65%. In Cycle II, all 4C competency indicators experienced remarkable growth, categorizing them as very high: critical thinking at 90%, collaboration at 95%, communication at 85%, and creativity at 90%.

The achievement of SKKNI competencies in the Pre-Cycle stage was suboptimal, with all indicators ranging from 20% to 30%. PPE compliance recorded the lowest achievement at 20%. However, in Cycle I, all competency elements improved, with hazard recognition skills reaching 70% and other indicators between 60% and 65%. By Cycle II, SKKNI competency achievements were very satisfactory, with hazard recognition and safe work procedure implementation reaching 90%, while PPE compliance and waste handling stood at 85%.

Teachers' performance in the Pre-Cycle stage indicated a need for improvement, with an overall score of 60%. In Cycle I, this score increased to 75%, but it still fell short of the minimum success indicator of 80%. In Cycle II, teachers demonstrated significant improvement, achieving a maximum score of 100%, surpassing the established success criteria.

Overall, the graph illustrates a consistent and significant upward trend from Pre-Cycle through Cycle I to Cycle II across all measured aspects. The implementation of internet-based learning strategies has proven effective in enhancing students' global competencies, meeting SKKNI competency standards, and improving teacher performance in managing learning.

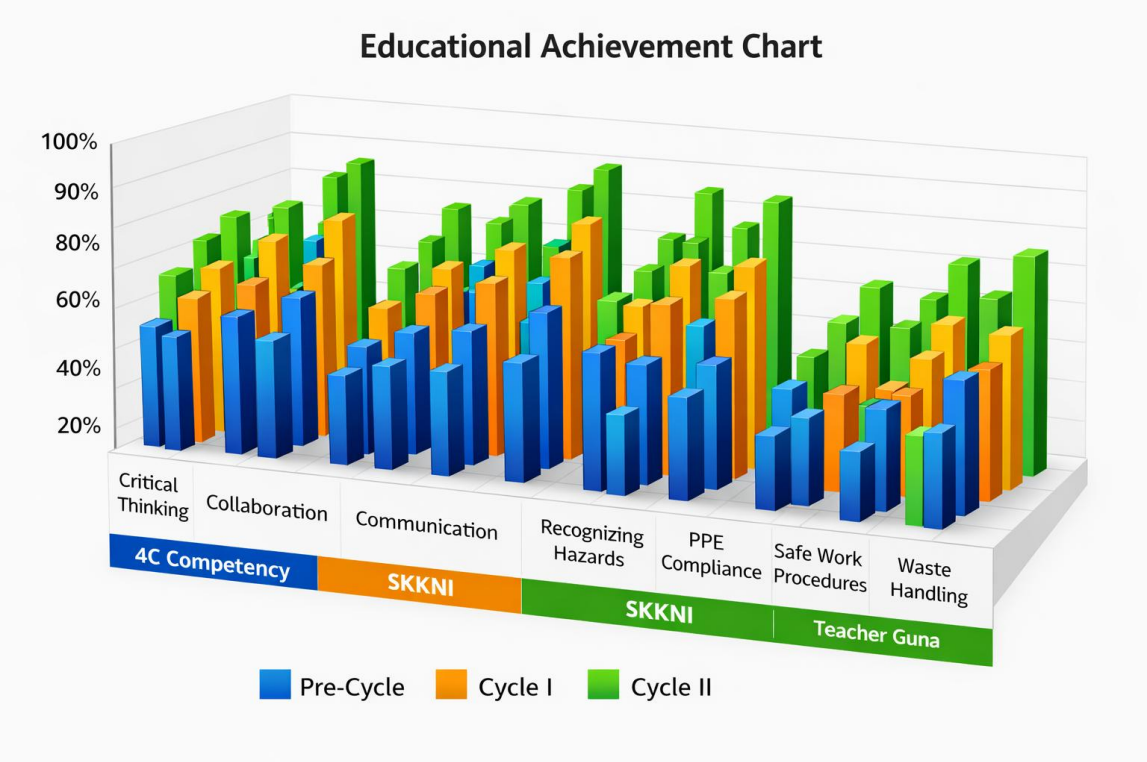

Figure 2. Educational Achievement Graph

Discussion

The study's findings indicate that integrating the internet as a learning medium significantly enhances students' global 4C competencies. The average achievement in these competencies rose from 30% in the pre-cycle phase to 60% in cycle I, ultimately reaching 90% in cycle II. This upward trend aligns with the perspectives of Saniuk et al. (2022) and Gajdzik & Wolniak (2022) and (Tyson & Zysman (2022), which assert that 4C skills are essential for 21st-century workers. The internet acts as an enabler, allowing students to access global information, validate digital resources, and collaborate across various platforms. This access accelerates the development of critical thinking, collaboration, communication, and creativity skills in the context of automotive SKKNI-based K3 (G.45OTO01.001.2).

Moreover, the internet's contribution to the 4C competencies demonstrates a consistent pattern, with varying dynamics across each dimension. Notably, the collaboration dimension experienced the most significant increase, rising from 35% to 95%. This suggests that the internet facilitates intensive digital cooperation through document-sharing platforms and online discussions. This observation supports the arguments presented in Rötkönen et al. (2022) and Benita et al. (2021), which emphasize that ICT expands learning interactions from physical to virtual environments, enabling trained students to collaborate in a digital ecosystem that mirrors a modern workplace.

The role of the internet significantly enhances SKKNI's competence. The percentage of competent students rose from 20% in the pre-cycle phase to 57% in cycle I and 86% in cycle II. This aligns with the theory presented in Sukackė et al. (2022) and Amadi (2023),

which posits that the quality of learning media directly influences learning outcomes. The internet enables students to compare local Standard Operating Procedures (SOPs) with global industry standards, visualize SKKNI-based K3 procedures (G.45OTO01.001.2) through simulation videos, and assess their understanding in context. In cycle II, the indicators for "skill in recognizing hazards" and "implementation of safe work procedures" reached 90%, demonstrating that the internet serves as a medium for validating work procedures. Students not only memorize SOPs but also compare them with the latest industry references. These results support Hassan et al. (2021), which asserts that integrating information technology is essential for developing vocational human resources that can adapt to industrial dynamics. Consequently, the internet effectively strengthens both the cognitive and psychomotor dimensions of students, bridging the gap between theoretical learning and practical application in the industry.

Simultaneous analysis showed that the internet acts as a catalytic variable that enhances the relationship between the 4C competency and SKKNI. The increase in 4C achievement from 30% to 90% is directly proportional to the rise in SKKNI completeness, which ranges from 20% to 86%, indicating a synergistic effect. Students trained in critical thinking through digital literacy are better at identifying occupational hazards, while those who collaborate effectively in digital teams show greater discipline in implementing SKKNI-based K3 procedures (G.45OTO01.001.2). This pattern supports the proposition Wohlfart & Wagner (2023) and Peng et al. (2023) that teachers' ability to systematically integrate technology fosters holistic learning, where the enhancement of soft skills (4C) and hard skills (SKKNI) mutually reinforces each other. The importance of these findings lies in the empirical evidence that, when managed with appropriate pedagogy, the internet can be a transformative tool in vocational education. The research results address a significant challenge in vocational schools: how to transform gadgets often seen as distractions into instruments for knowledge production. With targeted keyword guidance and problem-based tasks, the internet has shifted the role of smartphones from mere entertainment to a means of competency exploration, enabling students to become not only "technologically literate" but also "industry literate."

This research makes three significant contributions to the field of vocational education. First, it enhances the literature on internet-based learning models within productive vocational schools, particularly regarding SKKNI-based K3 subjects (G.45OTO01.001.2), which are typically taught using conventional methods. The findings on how to transform gadgets from distractions into learning tools provide practical strategies for vocational teachers in managing technology in the classroom.

Second, this study confirms that the 4C approach, when integrated with SKKNI standards, can produce graduates who are not only technically proficient but also equipped to navigate the complexities of the global workforce. This aligns with the insights from Pham et al. (2021) and Cavanagh & Kiersch (2023), which emphasize the need for practical solutions in response to the evolving landscape of 21st-century education.

Third, the research presents a teacher performance evaluation model that incorporates elements of digital pedagogy, 4C facilitation, and alignment with industry standards, serving as a valuable resource for advancing vocational teacher professionalism.

Theoretical implications: This study strengthens the conceptual framework that connects digital literacy, global competencies, and work competency standards. The findings show that the internet is not just an additional medium, but a structural variable that mediates the achievement of vocational competence. Practical implications: For vocational school teachers, the results of the study recommend the preparation of specific digital literacy guidelines (keywords, credible sources, problem-based assignments) to maximize the role of the internet. For school managers, these findings encourage investment in digital infrastructure and teacher training in technology-based pedagogy. For curriculum developers, the integration of 4C-SKKNI in SKKNI-based K3 materials (G.45OTO01.001.2) can be adopted as a learning model that is relevant to industry needs. Policy implications: This study provides an empirical basis for the formulation of digital learning policies in vocational schools, especially in the context of the digital transformation of national vocational education.

This research has several limitations. First, it was conducted at a single vocational school with a homogeneous student population (predominantly male, Class X TKRO), which limits the generalizability of the findings to other contexts. Second, the competency measurement of 4C and SKKNI is based on performance observations over a limited period of three months, leaving the long-term impact on graduates' work readiness unassessed. Third, external factors such as internet quality and the availability of devices at students' homes were not strictly controlled, potentially affecting the consistency of digital exploration. Lastly, this study focuses on SKKNI-based K3 material (G.45OTO01.001.2) within PDO subjects, which may limit the applicability of the findings to other productive subjects. These limitations highlight the need for further research with a longitudinal design, multi-site samples, post-graduate impact assessments, and the exploration of additional vocational subjects.

Conclusion

This study demonstrates that structured internet integration serves as a powerful catalyst in vocational education, simultaneously elevating students' 4C global competencies (from 30% to 90%) and SKKNI-based learning achievements (from 20% to 86%) in basic automotive work safety materials. The most important implication of these findings is the validation of a practical pedagogical model that enables teachers to transform students' gadgets from passive distractions into productive learning instruments, effectively bridging the gap between classroom instruction and actual industrial competence demands. Practically, vocational educators are strongly recommended to adopt these guided digital literacy micro-strategies to seamlessly align daily learning activities with both soft skill development and rigid industry standards. However, because this research was confined to a single vocational school over a short

three-month period, future studies should replicate this approach across diverse vocational institutions and employ longitudinal designs to comprehensively evaluate the long-term impact of such digital integration on graduates' actual job readiness and career retention in the modern workforce.

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