

Teacher competence and students' career interest: The mediating role of 21st-century skills in automotive vocational education

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ABSTRACT

This study examined the relationships among teachers' Technological Pedagogical Content Knowledge (TPACK), professional competence, students' 21st-century skills, and career interest in automotive vocational education. Using a quantitative explanatory survey design, data were collected from 174 students enrolled in nine vocational schools in Indonesia. The proposed model was tested using Partial Least Squares Structural Equation Modeling (PLS-SEM) to evaluate direct and indirect relationships among the variables. The findings revealed that both TPACK ($\beta = 0.43$, $p < 0.001$) and teachers' professional competence ($\beta = 0.35$, $p < 0.001$) significantly enhanced students' 21st-century skills. However, neither TPACK ($\beta = 0.06$, $p = 0.47$) nor professional competence ($\beta = 0.08$, $p = 0.34$) had a significant direct effect on students' career interest. In contrast, 21st-century skills exerted a strong positive influence on career interest ($\beta = 0.48$, $p < 0.001$). Mediation analysis further demonstrated that 21st-century skills serve as a significant intermediary mechanism linking teacher competence to students' career aspirations. The results suggest that teacher competence contributes to career development primarily through fostering transferable competencies such as critical thinking, communication, collaboration, creativity, and digital literacy. The study's novelty lies in integrating TPACK, teachers' professional competence, 21st-century skills, and Social Cognitive Career Theory (SCCT) into a unified explanatory model. Unlike previous studies that examined these variables separately, this research identifies 21st-century skills as the key pathway through which teacher competence influences career interest. The findings offer practical implications for vocational education by highlighting the importance of strengthening teacher competence, technology-integrated pedagogy, and the systematic integration of 21st-century skills into vocational curricula to better prepare students for future workforce demands.

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INTRODUCTION

Digital transformation driven by automation, artificial intelligence (AI), and industrial digitalization has fundamentally reshaped workforce competency requirements, particularly in the automotive and manufacturing sectors. As Industry 4.0 and Society 5.0 continue to reshape the world of work, employers are placing greater emphasis on graduates who combine technical expertise with a broad range of 21st-century competencies, particularly critical thinking, creativity, collaboration, communication, problem-solving, and digital literacy. These competencies are essential for adapting to technological disruption, enhancing employability, and sustaining long-term career development in digitally intensive work environments (Antera, 2021).

These developments pose significant challenges for vocational education and training (VET) institutions in preparing graduates with both occupational competence and transferable skills aligned

with industry needs (Pratama et al., 2026). Although vocational education traditionally emphasizes technical skill development, recent studies show that many VET systems still lack structured integration of transversal skills such as digital competence, collaboration, and problem-solving. As a result, a competency mismatch persists between graduates' capabilities and labor market expectations in technology-driven industries (Cattaneo et al., 2022; Misbah et al., 2022). Social Cognitive Career Theory (SCCT) explains that career interest is shaped by learning experiences, self-efficacy, outcome expectations, and environmental support. Within this framework, teachers play a central role in shaping students' motivation and career aspirations through instructional practices and learning environments that support the development of competence (Roll & Ifenthaler, 2021; Zhou et al., 2022).

Among the key competencies required of vocational teachers, Technological Pedagogical Content Knowledge (TPACK) and professional competence are essential for effective learning. TPACK supports the integration of technology, pedagogy, and content knowledge to promote student-centered instruction, while professional competence enables teachers to deliver industry-relevant learning through effective curriculum implementation, assessment, and relevant instructional design (Maknun, 2022; Santos & Castro, 2021). Although teacher competence is widely recognized as important, limited research has examined how TPACK and professional competence influence students' career interest by fostering 21st-century skills in vocational education. Therefore, this study investigates the direct and indirect relationships among TPACK, professional competence, 21st-century skills, and career interest in automotive vocational education (Rodríguez et al., 2024).

Although previous studies have extensively examined TPACK, teacher professional competence, and student learning outcomes, the existing body of literature remains fragmented in several respects. Research on TPACK has predominantly focused on technology integration, instructional effectiveness, digital learning environments, and academic achievement outcomes (Schmid et al., 2021). Meanwhile, studies on teachers' professional competence have largely emphasized instructional quality, curriculum implementation, and student performance, with limited attention to career-related outcomes in vocational settings (Santos & Castro, 2021). In contrast, career development studies grounded in Social Cognitive Career Theory (SCCT) have primarily examined psychological determinants such as self-efficacy, outcome expectations, social support, and career adaptability, while paying relatively little attention to teacher competencies as contextual antecedents of career interest (Antera et al., 2022; Mahmood et al., 2025).

This separation of research streams has resulted in an incomplete understanding of how teacher-related factors contribute to students' career development. Existing studies tend to investigate teacher competence, employability skills, and career outcomes independently, making it difficult to explain the mechanisms through which instructional experiences influence students' career orientations. Consequently, there remains a need for a more comprehensive framework that integrates instructional competence, transferable skill development, and career formation into a single explanatory model.

Furthermore, existing studies tend to examine teacher competence, 21st-century skills, employability, and career development as separate constructs. Empirical evidence investigating the mediating role of 21st-century skills in linking teacher competencies and career interest remains limited, particularly in automotive vocational education (Joho et al., 2024; Zhou et al., 2022). Given that 21st-century competencies have been identified as important predictors of employability, workforce readiness, and career success, a more integrated explanatory model is needed to clarify how teacher-related factors contribute to students' career orientation and future career intentions (Hirschi, 2009; Jiang et al., 2024).

The automotive vocational education context provides a particularly relevant setting for investigating these relationships. The automotive industry is undergoing a substantial transformation driven by Industry 4.0 technologies, including smart manufacturing, automation, artificial intelligence, digital diagnostics, connected vehicles, and data-driven maintenance systems. These developments have significantly altered workforce competency requirements, creating demand for employees who possess not only technical expertise but also strong transferable skills such as problem-solving, collaboration, adaptability, communication, and digital literacy (Antera & Teräs, 2024).

As a consequence, automotive vocational institutions face increasing pressure to prepare graduates who can respond effectively to rapidly changing industrial environments. The success of this preparation depends heavily on teachers' ability to integrate technology into instruction, maintain professional relevance to industry developments, and foster 21st-century competencies among students (Sudarsono et al., 2025). Despite the strategic importance of the automotive sector in many developing economies, empirical studies examining how teacher competencies contribute to students' career interest within automotive vocational education remain limited. Therefore, the automotive vocational context offers an appropriate and timely setting for investigating the interplay between teacher competence, transferable skills, and career development (Cui et al., 2024).

To address these gaps, this study proposes an integrated model that combines TPACK, teachers' professional competence, 21st-century skills, and Social Cognitive Career Theory (SCCT). The novelty of this study becomes evident when compared with previous research. Earlier studies generally examined TPACK as a predictor of technology integration and learning effectiveness, professional competence as a determinant of instructional quality, and SCCT variables as predictors of career-related outcomes in separate analytical frameworks. Very few studies have attempted to integrate these perspectives simultaneously, particularly within vocational education contexts.

Unlike prior studies that primarily focused on academic achievement, digital learning outcomes, or psychological determinants of career development, this study positions 21st-century skills as a mediating mechanism linking teacher competencies to students' career interest. By integrating TPACK and professional competence as contextual instructional resources and employing SCCT as the theoretical foundation for career-interest formation, this study offers a more comprehensive explanation of how vocational teachers contribute to students' career development. Therefore, the proposed model not only bridges previously disconnected research domains but also extends the application of SCCT by incorporating teacher competence and the development of transferable skills as critical antecedents of career interest. The proposed conceptual framework is presented in Figure 1.

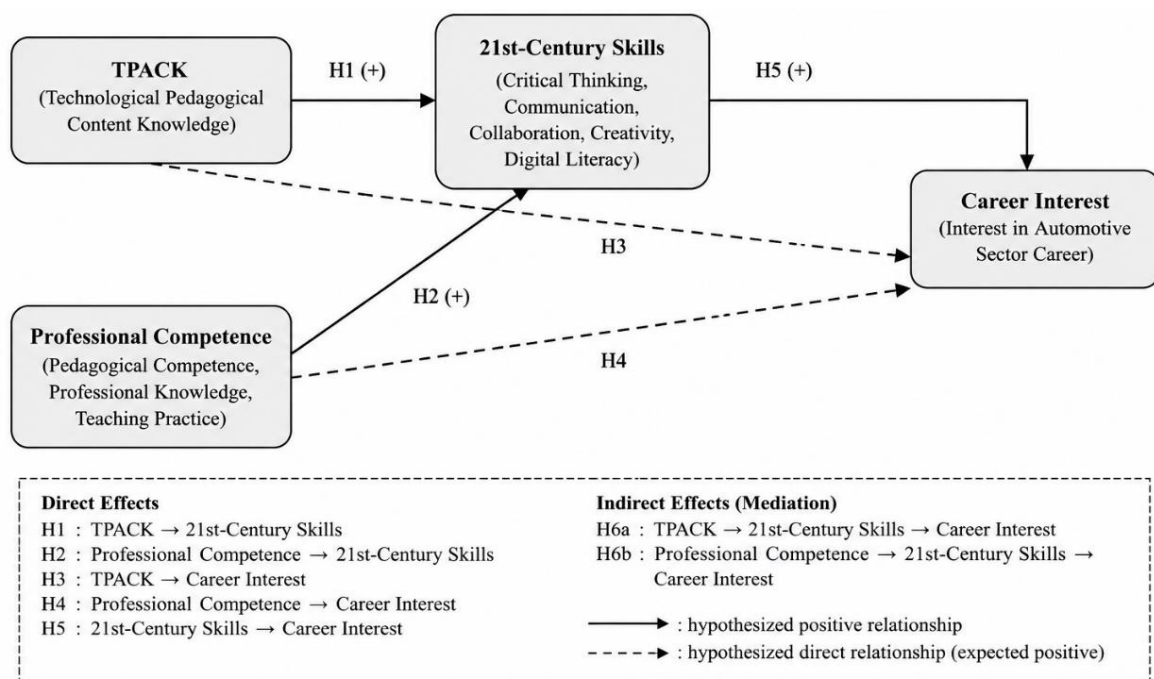


Figure 1. Proposed Conceptual Framework of the Relationship between Teacher Competence, 21st-century Skills, and Students' Career Interest

As illustrated in Figure 1, this study proposes that students' 21st-century skills mediate the relationship between teacher competencies and career interest. The conceptual framework assumes that teachers' TPACK and professional competence enhance students' transferable skills, which

subsequently foster stronger career interest in automotive vocational education. Accordingly, the model examines both the direct effects of teacher competencies on career interest and their indirect effects through 21st-century skills. Based on the proposed conceptual framework, this study examines the relationships among TPACK, teachers' professional competence, students' 21st-century skills, and career interest. It is hypothesized that both TPACK and teachers' professional competence positively influence students' 21st-century skills as well as their career interest. Furthermore, students' 21st-century skills are expected to positively influence career interest. Finally, this study proposes that students' 21st-century skills mediate the relationships between teacher competencies—represented by TPACK and professional competence—and students' career interest.

This study makes three main contributions. First, it extends Social Cognitive Career Theory (SCCT) by demonstrating how teacher competencies act as contextual factors that shape students' career interest through the development of transferable skills. Second, it integrates TPACK and professional competence into a single explanatory model, providing a more comprehensive understanding of teacher competence in vocational education. Third, it provides empirical evidence from automotive vocational education, a context that has received limited attention in studies of teacher competence, 21st-century skills, and career development. The study also advances the literature by validating an integrated framework that connects TPACK, professional competence, SCCT, and 21st-century skills.

From a practical perspective, the findings have implications for policymakers, school leaders, and teachers, highlighting the importance of strengthening teacher competencies and systematically integrating 21st-century skills into vocational learning. These efforts can enhance students' career readiness and improve the responsiveness of vocational education to the demands of Industry 4.0 and Society 5.0.

METHOD

This research adopted a quantitative explanatory survey to investigate the relationships among teachers' TPACK, professional competence, students' 21st-century skills, and career interest in automotive vocational education. In the conceptual model, TPACK and professional competence were treated as exogenous variables, 21st-century skills as the mediating construct, and career interest as the endogenous outcome. Guided by the TPACK framework, Social Cognitive Career Theory (SCCT), and the 21st-century skills framework, the hypothesized relationships were examined using Partial Least Squares Structural Equation Modeling (PLS-SEM). This analytical approach was selected because of its suitability for prediction-oriented studies, its ability to estimate complex relationships among latent constructs, and its robustness when the data do not fully satisfy multivariate normality assumptions (Sudarsono et al., 2024).

The population of this study consisted of final-year students enrolled in automotive vocational programs at vocational high schools in Indonesia. These students were selected because they were in a transitional stage toward entering the labor market or continuing their education, thereby clarifying their career orientation. The population comprised 428 final-year Automotive Engineering students across nine vocational schools, of whom 174 were selected via proportional random sampling.

The sample size was first determined using the Slovin formula to ensure adequate representation of the study population. Its appropriateness for PLS-SEM was then assessed against established sample size guidelines, which recommend a sample size greater than 10 times the highest number of structural paths leading to an endogenous construct. Since the proposed model contained a maximum of three incoming paths, at least 30 respondents were required. Moreover, PLS-SEM power analysis guidelines indicate that a sample size of more than 150 observations is sufficient to detect medium effect sizes with 80% power. Therefore, the final sample of 174 respondents met both the minimum sample size and statistical power requirements, providing adequate support for reliable estimation of the structural model.

All respondents included in the analysis were students. Although several teachers reviewed the questionnaire during the instrument development stage to evaluate item relevance and clarity, their responses were not included in the statistical analysis. Consequently, all constructs were

measured exclusively from students' perspectives. The participating vocational schools were selected because they offered Automotive Engineering programs, providing a relevant context for examining the proposed model. Involving students from multiple schools also increased sample diversity and strengthened the representativeness of the findings. Data were gathered using a structured questionnaire developed through a comprehensive review of the relevant literature. All items were rated on a five-point Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree).

The research questionnaire measured four primary constructs and their respective dimensions. First, teachers' TPACK was assessed across six dimensions: technology, pedagogy, content knowledge, and their intersections. Second, teachers' professional competence was evaluated based on subject-matter expertise, instructional planning, assessment practices, continuous professional development, and alignment with industry standards. Third, students' 21st-century skills were measured using indicators of critical thinking, creativity, communication, collaboration, and digital literacy. Finally, students' career Interest was examined through occupational attraction, career motivation, career confidence, long-term planning, and the specific intention to pursue a career in the automotive industry. To enhance transparency and replicability, the sources of constructs, dimensions, and measurement indicators are summarized in Table 1.

Table 1. Sources of Constructs and Measurement Indicators

Construct	Dimensions/Indicators	Source
TPACK	TK, PK, CK, TPK, TCK, TPACK	(Maknun, 2022)
Professional Competence	Subject mastery, instructional planning, assessment, professional development, industry relevance	(Antera & Teräs, 2024)
21st-Century Skills	Critical thinking, creativity, communication, collaboration, digital literacy	(Jiang et al., 2024)
Career Interest	Occupational attraction, career motivation, self-confidence, career planning, career commitment	(Hirschi, 2009)

Note: All constructs and measurement indicators were adapted from established theoretical frameworks and previous empirical studies. Each source is identified by the specific construct and measurement dimensions to ensure transparency in instrument development.

The research instrument was validated by three experts in vocational education, educational technology, and career development to ensure content validity, relevance, and alignment with the theoretical framework. Based on their feedback, several items were revised to improve clarity and minimize ambiguity. Prior to the main study, a pilot test involving 30 automotive vocational students from a non-sample school demonstrated satisfactory internal consistency, with Cronbach's alpha values exceeding 0.70. Minor adjustments to item wording and instructions were made post-pilot to optimize respondent comprehension before final administration.

To evaluate the empirical data, a two-phase PLS-SEM was performed using SmartPLS. The first phase focused on the measurement framework, validating indicators through reliability checks (Composite Reliability and Cronbach's alpha), convergent validity assessments (AVE and outer loadings), and discriminant validity checks (HTMT and Fornell–Larcker criteria). The second phase addressed hypothesis testing within the structural framework using a 5,000-resample bootstrapping approach that incorporated predictive metrics and a mediation analysis of students' 21st-century skills. Furthermore, diagnostics for Common Method Bias (CMB) ensured data integrity. Harman's single-factor test showed that the dominant factor accounted for less than half of the total variance, and the Variance Inflation Factor (VIF) values consistently remained under 3.3, indicating that CMB was negligible.

Ethical considerations were strictly maintained throughout the study. Institutional permission was secured from participating school principals, and written informed consent was obtained from all participants after briefing them on the study's purpose, voluntary nature, anonymity, and withdrawal rights. Because this non-interventional educational survey posed minimal risk and omitted sensitive personal data, a formal ethical review was completed in accordance with Ahmad Dahlan University's research policies. The procedures fully complied with the Declaration of Helsinki and institutional guidelines for human subject research.

RESULTS AND DISCUSSION

Results

Measurement Model Evaluation

To ensure a solid foundation for hypothesis testing, the measurement framework's validity and reliability were verified prior to estimating the structural model. Analysis of the indicators showed outer loadings ranging from 0.72 to 0.91, indicating robust item reliability. Internal consistency was confirmed by Cronbach's alpha values of 0.83–0.92 and composite reliability scores of 0.88–0.94. Furthermore, the constructs demonstrated convergent validity, with Average Variance Extracted (AVE) values ranging from 0.61 to 0.69, well above the required 0.50 threshold. These satisfactory psychometric properties collectively validate the outer model, justifying its use in the subsequent structural analysis.

Table 2. Convergent Validity and Reliability

Construct	Cronbach's Alpha	Composite Reliability	AVE
TPACK	0.91	0.94	0.67
Professional Competence	0.89	0.92	0.64
21st-century Skills	0.92	0.94	0.69
Career Interest	0.88	0.91	0.61

As shown in Table 2, all constructs exceeded the recommended thresholds for Cronbach's alpha (>0.70), composite reliability (>0.70), and AVE (>0.50). These results confirm that the measurement model possesses satisfactory reliability and convergent validity, supporting its suitability for subsequent structural model evaluation.

Discriminant Validity

Evaluation of discriminant validity was performed using both the Fornell–Larcker criterion and the Heterotrait–Monotrait (HTMT) ratio. As presented in Table 3, the square root of the AVE for each construct exceeded its correlations with all other constructs, satisfying the Fornell–Larcker criterion. This finding indicates that each latent variable shares greater variance with its own indicators than with other constructs, supporting adequate discriminant validity.

Table 3. Fornell–Larcker Criterion

Construct	TPACK	Professional Competence	21st-Century Skills	Career Interest
TPACK	0.82			
Professional Competence	0.58	0.80		
21st-century Skills	0.61	0.55	0.83	
Career Interest	0.29	0.32	0.54	0.78

Furthermore, as shown in Table 4, discriminant validity was also assessed using the HTMT ratio. All HTMT values ranged from 0.58 to 0.69, remaining well below the recommended threshold of 0.85. These results provide additional evidence that the constructs are empirically distinct and do not exhibit problematic overlap.

Table 4. Heterotrait–Monotrait (HTMT) Ratio

Construct	HTMT Value
TPACK – Professional Competence	0.63
TPACK – 21st-Century Skills	0.69
Professional Competence – 21st-Century Skills	0.64
21st-century Skills – Career Interest	0.58

Taken together, the results presented in Tables 3 and 4 confirm that the measurement model satisfies the established criteria for discriminant validity. Therefore, each latent construct represents

a distinct theoretical concept, providing a sound basis for subsequent structural model analysis and hypothesis testing.

Structural Model Evaluation

The structural model was assessed using bootstrapping with 5,000 resamples. As presented in Table 5, TPACK significantly predicted students' 21st-century skills ($\beta = 0.43$, $t = 6.020$, $p < 0.001$), supporting H1. Similarly, professional competence had a significant positive effect on 21st-century skills ($\beta = 0.35$, $t = 4.880$, $p < 0.001$), supporting H2. However, the direct effects of TPACK ($\beta = 0.06$, $p = 0.470$) and professional competence ($\beta = 0.08$, $p = 0.340$) on career interest were not significant, leading to the rejection of H3 and H4. In contrast, 21st-century skills significantly predicted career interest ($\beta = 0.48$, $t = 6.540$, $p < 0.001$), supporting H5. Overall, these findings suggest that teacher competencies influence students' career interest primarily through the development of 21st-century skills rather than through direct effects.

Table 5. Structural Model Results

Hypothesis	Path	β	t-value	p-value	Decision
H1	TPACK $\rightarrow$ 21st-Century Skills	0.430	6.020	0.000	Supported
H2	Professional Competence $\rightarrow$ 21st-Century Skills	0.350	4.880	0.000	Supported
H3	TPACK $\rightarrow$ Career Interest	0.060	0.710	0.470	Not Supported
H4	Professional Competence $\rightarrow$ Career Interest	0.080	0.940	0.340	Not Supported
H5	21st-century Skills $\rightarrow$ Career Interest	0.480	6.540	0.000	Supported

The findings presented in Table 5 indicate that both teachers' TPACK and professional competence contribute significantly to the development of students' 21st-century skills. This result suggests that transferable competencies in vocational education are fostered through teachers' ability to integrate technology effectively and deliver instruction that reflects professional and industrial standards. The stronger effect of TPACK ($\beta = 0.43$) compared with professional competence ($\beta = 0.35$) further implies that technology-enhanced instructional practices may play a particularly important role in developing critical thinking, communication, collaboration, creativity, and digital literacy among automotive vocational students.

Conversely, Table 5 also shows that neither TPACK nor professional competence had a significant direct effect on students' career interest. This finding indicates that students' perceptions of teacher competence alone are insufficient to strengthen their career aspirations. Instead, career interest appears to develop when teacher competencies are translated into meaningful learning experiences that enable students to acquire relevant 21st-century skills. Thus, the influence of teacher competence on career interest is more likely to occur indirectly through students' competency development than through a direct instructional effect.

Coefficient of Determination (R^2)

The explanatory power of the structural model was evaluated using the coefficient of determination (R^2). As presented in Table 6, TPACK and professional competence explained 46% of the variance in students' 21st-century skills ($R^2 = 0.46$) and 31% of the variance in career interest ($R^2 = 0.31$). According to the established criteria, both values indicate moderate explanatory power. Overall, these findings suggest that the proposed model provides stronger predictive capability for 21st-century skills than for career interest.

Table 6. R-square Results

Variable	R^2	Interpretation
21st-Century Skills	0.46	Moderate
Career Interest	0.31	Moderate

The results presented in Table 6 provide additional evidence of the model's explanatory capability. The higher R^2 value for 21st-century skills (0.46) indicates that teacher-related competencies, particularly TPACK and professional competence, represent important determinants of students' transferable skill development. In contrast, the lower R^2 value for career interest (0.31) suggests that students' career aspirations are shaped by a broader range of factors beyond those included in the present model. These factors may include self-efficacy, parental support, labor-market perceptions, occupational expectations, and prior career-related experiences. This finding is consistent with the assumptions of Social Cognitive Career Theory (SCCT), which emphasizes that career development results from the interaction of multiple personal, behavioral, and environmental influences.

Effect Size (f^2)

Effect size (f^2) analysis was conducted to evaluate the contribution of each exogenous construct to the endogenous constructs. As presented in Table 7, TPACK ($f^2 = 0.21$) and professional competence ($f^2 = 0.16$) exerted medium effects on students' 21st-century skills, while 21st-century skills demonstrated a medium effect on career interest ($f^2 = 0.28$). According to Cohen's effect size criteria, these findings indicate that the significant relationships identified in the structural model are not only statistically significant but also of practical importance.

Table 7. Effect Size

Path	f^2	Effect
TPACK → 21st-century Skills	0.21	Medium
Professional Competence → 21st-century Skills	0.16	Medium
21st-century Skills → Career Interest	0.28	Medium

The findings presented in Table 7 demonstrate that the significant relationships identified in the structural model have meaningful practical implications. The medium effect sizes of TPACK and professional competence suggest that improvements in teachers' technological and professional competencies can make a substantial contribution to the development of students' 21st-century skills. Furthermore, the relatively stronger effect of 21st-century skills on career interest ($f^2 = 0.28$) highlights the critical role of transferable competencies in shaping students' career aspirations. In vocational education, where learning is expected to prepare students for dynamic workplace demands, these findings emphasize the importance of instructional strategies that strengthen students' critical thinking, communication, collaboration, creativity, and digital literacy.

Predictive Relevance (Q^2)

The model's predictive relevance was assessed using Stone–Geisser's Q^2 statistic obtained through the blindfolding procedure. As presented in Table 8, the Q^2 values were 0.29 for 21st-century skills and 0.21 for career interest. Since both values are greater than zero, the structural model demonstrates adequate predictive relevance for the endogenous constructs.

Table 8. Predictive Relevance

Variable	Q^2
21st-century Skills	0.29
Career Interest	0.21

The results presented in Table 8 confirm that the proposed model possesses satisfactory predictive capability. The higher Q^2 value for 21st-century skills (0.29) indicates that the model has stronger predictive relevance for students' transferable skill development than for career interest ($Q^2 = 0.21$). Nevertheless, the positive Q^2 values for both endogenous constructs demonstrate that the model has acceptable out-of-sample predictive performance, supporting its suitability for explaining and predicting the relationships among teacher competencies, 21st-century skills, and career interest.

Mediation Analysis

To examine the mechanism through which teacher competencies influence students' career interest, a mediation analysis was conducted using the bootstrapping procedure with 5,000 resamples. As presented in Table 9, the indirect effect of TPACK on career interest through 21st-century skills was statistically significant ($\beta = 0.21$, $t = 4.10$, $p < 0.001$), with the 95% confidence interval excluding zero. Likewise, professional competence exerted a significant indirect effect on career interest through 21st-century skills ($\beta = 0.17$, $t = 3.65$, $p < 0.001$), and its confidence interval also excluded zero. These findings confirm that 21st-century skills serve as a significant mediating mechanism linking teacher competencies to students' career interest.

Table 9. Bootstrapping Results of Mediation Analysis

Indirect Effect Path	β	t-value	p-value	95% Confidence Interval	Decision
TPACK → 21st-Century Skills → Career Interest	0.21	4.10	<0.001	[0.12, 0.32]	Supported
Professional Competence → 21st-Century Skills → Career Interest	0.17	3.65	<0.001	[0.08, 0.27]	Supported

Note: Indirect effects were tested using bootstrapping with 5,000 resamples. A mediation effect was considered significant when the confidence interval did not include zero.

The findings presented in Table 9 indicate that teacher competencies influence students' career interest primarily through indirect rather than direct pathways. Specifically, TPACK and professional competence enhance students' career interest by fostering the development of 21st-century skills, including critical thinking, creativity, communication, collaboration, and digital literacy. These results provide empirical evidence that 21st-century skills function as a key mediating mechanism through which teachers' instructional and professional capabilities are translated into positive career-development outcomes among vocational students.

Discussion

This study demonstrates that TPACK and professional competence significantly contribute to the development of students' 21st-century skills. Rather than merely confirming previous findings, the results suggest that teacher competence functions as a mechanism for translating technological and disciplinary knowledge into learning experiences that foster transferable skills (Rehman et al., 2024; Silor & Silor, 2025; Tripon, 2025). In automotive vocational education, where students are expected to adapt to rapidly evolving technologies, the value of teacher competence lies not only in improving instructional quality but also in preparing students to navigate uncertain, technology-intensive work environments. This finding extends previous research by showing that TPACK contributes to employability-related competencies, particularly critical thinking, collaboration, communication, creativity, and digital literacy (Jiang et al., 2024; Löfgren et al., 2023).

The positive effect of professional competence further indicates that industry-relevant expertise remains important in vocational education. However, the contribution of professional competence appears to be less about transmitting occupational knowledge and more about helping students connect classroom learning with workplace expectations. This finding is particularly relevant to the automotive sector, where technological disruption continuously reshapes required competencies and job roles (Lucas & Spencer, 2022; Mejeh & Held, 2022).

A notable finding is that neither TPACK nor professional competence directly influences career interest. This result challenges the common assumption that improving teacher competence will automatically strengthen students' career aspirations (Sukacké et al., 2022). One explanation is that career interest is a distal outcome that develops through accumulated learning experiences and self-perceptions rather than through exposure to competent teaching alone. Students may acknowledge teacher competence, yet such perceptions do not necessarily translate into career aspirations unless they also develop confidence, adaptability, and a sense of readiness for future work (Parenrengi et al., 2025).

This finding also helps explain why previous studies have reported inconsistent results. Research examining teacher support often focuses on psychosocial dimensions such as

encouragement, mentoring, and emotional support, which are more directly related to career decision-making (Prianto et al., 2021). In contrast, this study examines teacher competence as an instructional resource. Therefore, the absence of a direct effect suggests that instructional competence and psychosocial support influence career development through different mechanisms. Teacher competence appears to shape career interest indirectly by strengthening students' transferable skills and perceptions of employability rather than by directly influencing career preferences (Ramírez et al., 2024).

The mediation results provide the most important contribution of this study. The significant indirect effects indicate that 21st-century skills serve as the mechanism through which teacher competence influences career interest. This finding extends SCCT by showing that contextual educational resources affect career outcomes only when they are transformed into personal competencies that students perceive as relevant for future employment. Thus, transferable skills are not merely educational outcomes but strategic resources linking vocational learning experiences with career development (Santos & Castro, 2021).

Recent empirical studies increasingly demonstrate that career-related outcomes are shaped through indirect mechanisms involving personal and psychological resources. Career decision-making self-efficacy and career adaptability sequentially mediate the relationship between career calling and learning engagement among vocational education students. Similarly, recent evidence indicates that psychological well-being mediates the relationship between self-efficacy and career development outcomes (Maknun, 2022), while career decision-making self-efficacy has been shown to mediate the relationship between career-seeking self-efficacy and student outcomes in vocational education settings (González-Pérez & Ramírez-Montoya, 2022). These findings reinforce the present study's results by highlighting that career-related outcomes are often influenced by intermediate competencies and psychological resources, rather than by direct contextual influences. In this study, 21st-century skills represent a similar developmental mechanism through which teacher competence contributes to students' career interest (Ebner & Paul, 2023; Hirschi, 2009; Jiang et al., 2024).

These findings are particularly important in the Indonesian vocational education context. Despite ongoing efforts to strengthen link-and-match policies, employers continue to report gaps in graduates' adaptability, communication, problem-solving, and digital competencies. In the automotive industry, the transition toward automation, smart manufacturing, digital diagnostics, and electric vehicle technologies has increased the demand for workers with both technical expertise and transferable skills. Consequently, the findings suggest that vocational schools should move beyond a narrow focus on technical competence and place greater emphasis on learning environments that systematically cultivate 21st-century skills (Joho et al., 2024; Schmid et al., 2021).

From a theoretical perspective, the study contributes by integrating TPACK, professional competence, 21st-century skills, and SCCT into a single explanatory framework. The results indicate that teacher competence influences career development indirectly through skill-development processes, thereby highlighting the importance of considering mediating mechanisms when examining educational contributions to career outcomes. This perspective offers a more nuanced explanation than previous approaches that treated teacher competence and career development as separate domains of inquiry.

CONCLUSION

This study demonstrates that teachers' TPACK and professional competence significantly enhance students' 21st-century skills, which subsequently drive career interest in automotive vocational education. Rather than through a direct pathway, teacher competencies influence students' career interest indirectly by fostering essential transferable skills such as critical thinking, collaboration, and digital literacy. Theoretically, this extends Social Cognitive Career Theory (SCCT) by framing teacher competencies as vital contextual resources and enriching the vocational literature with a unified framework that integrates TPACK, professional competence, 21st-century skills, and career interest. Practically, these insights emphasize the importance of upgrading teachers' technological-pedagogical expertise and systematically embedding 21st-century skills into vocational curricula. Educational institutions should prioritize technology-integrated pedagogy,

continuous professional development, and closer industry engagement. Implementing these strategies will better prepare educators to cultivate the core competencies necessary to boost student employability and career readiness. However, several limitations warrant consideration. The study's cross-sectional design precludes definitive causal inference, and the self-reported data introduce potential common method bias, while the specific focus on automotive education limits generalizability. To overcome these constraints, future research should adopt longitudinal or multi-source designs, incorporate complementary SCCT variables such as self-efficacy and career adaptability, and test the structural model across diverse vocational fields to broaden its empirical scope.

AUTHOR CONTRIBUTIONS STATEMENT

This journal uses the Contributor Roles Taxonomy (CRediT) to recognize individual author contributions, reduce authorship disputes, and facilitate collaboration.

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C : Conceptualization I : Investigation Vi : Visualization
 M : Methodology R : Resources Su : Supervision
 So : Software D : Data Curation P : Project administration
 Va : Validation O : Writing - Original Draft Fu : Funding acquisition
 Fo : Formal analysis E : Writing - Review & Editing

CONFLICT OF INTEREST STATEMENT

The authors declare that they have no known competing financial or non-financial interests that could have appeared to influence the work reported in this paper.

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