Assyfa Journal of Multidisciplinary Education

AJME. Vol. 3 No. 1 (2025) 93-107

e-ISSN: 3047-3942 p-ISSN: 3047-3942

Check for updates

OPEN ACCESS

DOI: 10.61650/ajme.v3i1.1426

ORIGINAL RESEARCH ARTICLE

Vocational High School Teachers' Readiness for Electric Vehicle Diagnostic Learning Based on Robotics and Artificial Intelligence: The Role of TPACK, Personal Factors, and Contextual Factors

Cantika Yunitasari Adri Putri[1*], Akhmad Zakaria Adi Prasetyo[1], Alvin Arilian[1], Ammar Najiibulloh An Nabhan[1], Ayoub Eka Bekti[1], Brema Ady Putra Sembiring[1], Fani Ikko Armalia[1]

[1]Automotive Engineering Education Study Program, Universitas Negeri Malang, Indonesia

Correspondence: **cantika.yunitasari.2022456@stundent.um.ac.id**

Article History: Received: 12 January 2025 • Revised: 25 February 2025 • Accepted: 30 March 2025 • Published: 30 March 2025

ABSTRACT

The transformation of automotive technology toward electric vehicles, integrated electronic systems, robotics, and artificial intelligence (AI) requires vocational learning that is increasingly oriented toward data-based diagnosis. Teacher readiness is an important prerequisite for translating technological change into relevant learning experiences in vocational high schools (Sekolah Menengah Kejuruan, SMK). This study aimed to describe the levels of *technological pedagogical content knowledge* (TPACK), personal factors, contextual factors, and teacher readiness, and to analyze the relationships of these three factors with SMK teachers' readiness for electric vehicle diagnostic learning based on robotics and AI in Blitar Regency and Blitar City, Indonesia. A quantitative approach with a descriptive-correlational design was employed. The population comprised 100 Light Vehicle Automotive Engineering teachers, and the analytic sample consisted of 80 teachers. Data were collected through a Likert-scale questionnaire and analyzed using descriptive statistics and multiple linear regression. The mean scores were 26.8750 (SD = 5.01990) for TPACK, 24.1750 (SD = 4.08385) for personal factors, 14.4750 (SD = 3.83843) for contextual factors, and 32.4250 (SD = 5.54333) for teacher readiness. The regression model was simultaneously significant, $F = 58.731$, $p < .001$. Partially, personal factors were positively and significantly associated with teacher readiness ($B = 0.793$; $t = 6.234$; $p < .001$), whereas TPACK ($B = 0.278$; $t = 1.965$; $p = .053$) and contextual factors ($B = 0.146$; $t = 1.036$; $p = .303$) were not significant at the 5% level. These findings position personal factors as the strongest partial predictor according to the reported t statistics, but they do not demonstrate that technological competence or school support is unimportant. Interpretation should take into account the limitations of the survey design, perception-based measurement, and the departure from linearity for contextual factors. The practical implication is that teacher professional development should combine the strengthening of self-efficacy, hands-on experience, electric vehicle diagnostic training, and measurable institutional support.

Keywords: Artificial Intelligence; Electric Vehicles; Personal Factors; Teacher Readiness; TPACK; Vocational Education.

ABSTRAK

Transformasi teknologi otomotif menuju kendaraan listrik, sistem elektronik terintegrasi, robotika, dan kecerdasan buatan (*artificial intelligence*/AI) menuntut pembelajaran kejuruan yang semakin berorientasi pada diagnosis berbasis data. Kesiapan guru menjadi prasyarat penting agar perubahan teknologi dapat diterjemahkan menjadi pengalaman belajar yang relevan di Sekolah Menengah Kejuruan (SMK). Penelitian ini bertujuan mendeskripsikan tingkat *technological pedagogical content knowledge* (TPACK), faktor personal, faktor kontekstual, dan kesiapan guru, serta menganalisis hubungan ketiga faktor tersebut dengan kesiapan guru SMK dalam pembelajaran diagnostik kendaraan listrik berbasis robotika dan AI di Kabupaten dan Kota Blitar. Penelitian menggunakan pendekatan kuantitatif dengan desain deskriptif-korelasional. Populasi penelitian berjumlah 100 guru bidang Teknik Kendaraan Ringan Otomotif, sedangkan sampel analisis berjumlah 80 guru. Data dikumpulkan melalui kuesioner skala Likert dan dianalisis menggunakan statistik deskriptif serta regresi linear berganda. Rata-rata TPACK sebesar 26,8750 (SD = 5,01990), faktor personal 24,1750 (SD = 4,08385), faktor kontekstual 14,4750 (SD = 3,83843), dan kesiapan guru 32,4250 (SD = 5,54333). Model regresi secara simultan signifikan, $F = 58{,}731$, $p < 0{,}001$. Secara parsial, faktor personal berhubungan positif dan signifikan dengan kesiapan guru ($B = 0{,}793$; $t = 6{,}234$; $p < 0{,}001$), sedangkan TPACK ($B = 0{,}278$; $t = 1{,}965$; $p = 0{,}053$) dan faktor kontekstual ($B = 0{,}146$; $t = 1{,}036$; $p = 0{,}303$) tidak signifikan pada taraf 5%. Temuan ini menempatkan faktor personal sebagai prediktor parsial yang paling kuat menurut statistik t yang dilaporkan, tetapi tidak membuktikan bahwa kompetensi teknologi atau dukungan sekolah tidak penting. Interpretasi perlu mempertimbangkan keterbatasan desain survei, pengukuran berbasis persepsi, dan penyimpangan linearitas pada faktor kontekstual. Implikasi praktisnya adalah pengembangan profesional guru perlu menggabungkan penguatan efikasi diri, pengalaman praktik, pelatihan diagnostik kendaraan listrik, dan dukungan institusi yang terukur.

Kata Kunci: Kecerdasan Buatan; Kendaraan Listrik; Faktor Personal; Kesiapan Guru; TPACK; Pendidikan Vokasi.

How to cite: Putri, C. Y. A., Arilian, A., Nabhan, A. N. A., Bekti, A. E., Sembiring, B. A. P., Armalia, F. I., & Prasetyo, A. Z. A. (2025). Vocational High School Teachers' Readiness for Electric Vehicle Diagnostic Learning Based on Robotics and Artificial Intelligence: The Role of TPACK, Personal Factors, and Contextual Factors. *Assyfa Journal of Multidisciplinary Education*, *3*(1). Retrieved from https://journal.assyfa.com/index.php/ajme/article/view/1426

1. INTRODUCTION

Changes in automotive technology have broadened the competencies that vocational education must develop. Modern vehicles can no longer be understood merely as mechanical systems, because their operation depends on sensors, electronic control units, inter-module communication, software, and data-based diagnostic processes. In electric vehicles, this complexity extends to battery management systems, inverters, electric motors, high-voltage safety systems, and in-vehicle communication networks (Yang, 2024; Klimushyn et al., 2025). Diagnosis therefore increasingly requires an understanding of the relationships among symptoms, sensor data, fault codes, and subsystem conditions. Learning in vocational high schools (SMK) needs to respond to these changes so that students' competencies do not lag behind the maintenance and repair practices that are evolving in industry.

Robotics and artificial intelligence (AI) add both opportunities and challenges to diagnostic learning. AI-based systems can help recognize failure patterns, process data, and support predictive

© 2025 The Author(s). Published by CV. Bimbingan Belajar Assyfa, Indonesia

maintenance (Hossain et al., 2024). Robotics can provide a context for understanding control systems, actuators, sensors, and automation. However, using these technologies in learning is not simply a matter of introducing devices or applications. Teachers need to connect technical concepts with learning objectives, select appropriate pedagogical strategies, manage practical work safely, and evaluate whether students understand the fundamentals of diagnosis or merely follow operational steps. Meaningful technology integration therefore depends on teacher competence and readiness, not solely on the availability of equipment.

The literature reviewed in this study indicates that the integration of educational technology is related to digital competence, attitudes toward innovation, training, and the school environment (Peng et al., 2023). Yue, Jong, and Ng (2024), in a study of 1,664 K–12 teachers, reported gaps in AI-related content and technological knowledge and emphasized the need for specific professional development. Ning et al. (2024) likewise positioned technological, pedagogical, and content knowledge as interrelated elements of AI-TPACK. These findings suggest that readiness to teach with AI is not only a matter of skill in operating devices but also of the ability to select content, design learning experiences, and direct the use of technology in line with students' needs (Kim, 2025).

Teacher readiness, however, cannot be explained by technological competence alone. Belief in one's ability to teach new material, persistence in the face of obstacles, motivation, experience, and attitudes toward change may influence teachers' decisions to try new instructional approaches. Personal factors are particularly relevant when the subject matter evolves rapidly and teachers must relearn outside their established teaching routines. In the context of electric vehicle technology, a teacher may possess adequate pedagogical knowledge yet remain hesitant to teach diagnosis because they have never operated the equipment or are not confident that they can answer students' technical questions. Self-efficacy and readiness to face change therefore need to be considered together with professional competence.

Contextual support may also shape teachers' opportunities to implement innovative learning. The availability of practical equipment, software, access to training, school policies, principal support, and collaboration among teachers can facilitate the use of technology (Yuniarti & Walajro, 2024). Competence development is difficult to realize if teachers lack the time, facilities, or opportunities to practice the skills they have acquired. Conversely, adequate facilities do not automatically guarantee changes in instruction if teachers do not yet have the confidence and competence to use them. The relationship between personal and contextual factors therefore deserves empirical testing rather than being assumed to always operate in the same direction or to exert equal influence in every context.

In the Indonesian context, SMKs are expected to prepare graduates who can adapt to changes in work and technology. Research cited in this study links vocational capability and perceptions of technological innovation with adaptation to changes in the world of work (Erlitasari et al., 2025). Studies on the development of interactive teaching materials and teacher training also show the importance of support for building relevant instructional practices (Azizah et al., 2025; Suhaedin et al., 2024). Nevertheless, general evidence on technology integration does not by itself explain

© 2025 The Author(s). Published by CV. Bimbingan Belajar Assyfa, Indonesia

which factors are most closely related to teachers' readiness to teach robotics- and AI-based electric vehicle diagnosis in regional automotive SMKs.

Preliminary observations in several SMKs in Blitar Regency and Blitar City indicated that some teachers were not yet fully prepared to implement robotics- and AI-based electric vehicle diagnostic learning. The constraints identified included operating digital diagnostic equipment, understanding the application of AI and robotics, digital literacy, using diagnostic software, and limited facilities. This preliminary observational information is used as the problem context and not as a main survey result from the 80 respondents.

The research problem focuses on three factors expected to be related to teacher readiness, namely TPACK, personal factors, and contextual factors. TPACK represents the integration of technological, pedagogical, and content knowledge. In the research instrument, personal factors were operationalized mainly through statements about self-belief, the ability to teach new material, confidence in keeping up with technological developments, and persistence in overcoming obstacles. Contextual factors include the availability of facilities, training, school support, an innovative environment, and support from colleagues. Teacher readiness, as the dependent variable, encompasses readiness to teach, to use technology, to prepare learning materials, to adapt, mental readiness, and readiness to face the challenges of modern learning.

Studies of AI-TPACK and technology integration have grown, but applying their results to electric vehicle diagnostic learning in vocational education involves a specific context. This subject combines automotive knowledge, electronic systems, workshop practice, safety, the use of diagnostic equipment, and an understanding of AI. In addition, the relationships among TPACK, personal factors, and contextual factors need to be tested simultaneously to determine whether each variable shows a unique relationship with readiness after the other variables are taken into account. This study provides a contextual contribution by testing these three predictors among Light Vehicle Automotive Engineering (Teknik Kendaraan Ringan Otomotif, TKRO) teachers in Blitar Regency and Blitar City. Its novelty is framed as contextual empirical evidence and as a pattern of relationships among variables, not as a claim that teacher readiness or TPACK has never been studied before.

The objectives of this study were (1) to describe the levels of TPACK, personal factors, contextual factors, and teacher readiness; (2) to test the partial relationship between TPACK and teacher readiness; (3) to test the partial relationship between personal factors and teacher readiness; (4) to test the partial relationship between contextual factors and teacher readiness; and (5) to test the simultaneous relationship of the three predictors with teacher readiness. The study hypothesized that the three independent variables positively influence teacher readiness, both partially and simultaneously, and sought to identify the most dominant predictor. Because the design is a correlational survey, the term "influence" in this article is interpreted as a statistical association within the regression model, not as evidence of causality.

© 2025 The Author(s). Published by CV. Bimbingan Belajar Assyfa, Indonesia

2. RESEARCH METHODS

This study used a quantitative approach with a descriptive-correlational design. The descriptive approach was used to describe the scores of each variable, whereas the correlational analysis was used to test the statistical relationships among TPACK, personal factors, contextual factors, and teacher readiness. Data were collected through a survey using a Likert-scale questionnaire and analyzed with descriptive statistics, assumption tests, and multiple linear regression.

The population consisted of 100 Light Vehicle Automotive Engineering (TKRO) teachers in nine SMKs in Blitar Regency and Blitar City. The analytic sample comprised 80 teachers. The sample size was calculated using the Slovin formula at a 5% margin of error, and respondents were selected through proportional purposive sampling, that is, selection based on the research criteria while taking into account the proportion of teachers at each school. The schools covered were SMKN 1 Blitar, SMK Islam 1 Blitar, SMKS PGRI Wlingi, SMKN 1 Panggungrejo, SMKN 1 Kademangan, SMKN 1 Nglegok, SMK Katolik Santo Yusup Blitar, SMK PGRI 1 Kota Blitar, and SMKN 1 Doko.

The instrument covered four constructs (Table 1). The analyzed TPACK score (X1) consisted of seven items. Personal factors (X2) consisted of six valid items that mainly represented confidence in teaching new material, mastery of the material, keeping up with technological developments, and dealing with obstacles. Contextual factors (X3) initially contained six items; items X3.4 and X3.5 were found to be invalid and were eliminated, so four valid items were used in the analysis. Teacher readiness (Y) consisted of eight valid items. All items used a five-point Likert scale ranging from 1 = strongly disagree to 5 = strongly agree.

Table 1. Operationalization of variables and instrument

Variable	No. of items	Indicator coverage	Scale
TPACK (X1)	7 (analyzed)	Integration of technology, pedagogy, and automotive/diagnostic content	Likert 1–5
Personal factors (X2)	6	Mainly self-belief in teaching new material and overcoming obstacles	Likert 1–5
Contextual factors (X3)	4 valid of 6	Facilities, training, school support, innovative environment, colleagues	Likert 1–5
Teacher readiness (Y)	8	Readiness to teach, use technology, prepare learning materials, and adapt	Likert 1–5

Item validity was tested using Pearson product-moment correlation with a critical r value of 0.444. Seven TPACK items, six personal factor items, and eight teacher readiness items were valid. For the contextual factor construct, four items were valid, while X3.4 and X3.5 were invalid and excluded from the analysis. The reported Cronbach's alpha coefficients were 0.866 for TPACK, 0.863 for personal factors, 0.731 for contextual factors, and 0.882 for teacher readiness, all exceeding the 0.60 criterion.

© 2025 The Author(s). Published by CV. Bimbingan Belajar Assyfa, Indonesia

The analysis included descriptive statistics, a normality test, a linearity test, and multiple linear regression. The Kolmogorov–Smirnov test was reported to have a significance of 0.200; because the object of the test was not explicitly stated, this result was not considered definitive confirmation of residual normality. The deviation from linearity values were 0.135 for TPACK, 0.070 for personal factors, and < 0.001 for contextual factors. The result for contextual factors indicates a significant departure from a linear pattern, so its regression coefficient must be interpreted with caution.

The regression model was specified as $Y = a + b_1X_1 + b_2X_2 + b_3X_3 + e$, where Y is teacher readiness, X_1 is TPACK, X_2 is personal factors, X_3 is contextual factors, and e is the error term. The simultaneous test was conducted using the F test and the partial tests using t tests at $\alpha = 0.05$. The estimated equation was $\hat{Y} = 3.690 + 0.278X_1 + 0.793X_2 + 0.146X_3$. The reported coefficients are unstandardized regression coefficients.

3. RESULTS AND FINDINGS

Descriptive statistics

The main analysis used data from 80 teachers. Descriptive statistics showed a mean total score of 26.8750 (SD = 5.01990) for TPACK, 24.1750 (SD = 4.08385) for personal factors, 14.4750 (SD = 3.83843) for contextual factors, and 32.4250 (SD = 5.54333) for teacher readiness (Table 2). The TPACK score reflects seven items (empirical maximum 35), whereas the contextual factor score reflects four valid items (empirical maximum 20). Because the number of items differs, comparisons were made using the mean per item rather than the total mean.

Table 2. Descriptive statistics of the research variables

Variable	N	Mean	Median	SD	Min	Max
TPACK (X1)	80	26.8750	28.0000	5.01990	11	35
Personal factors (X2)	80	24.1750	25.0000	4.08385	9	30
Contextual factors (X3)	80	14.4750	15.0000	3.83843	6	20
Teacher readiness (Y)	80	32.4250	34.0000	5.54333	12	40

Source: results of the descriptive statistical analysis.

Figure 1 presents the mean score per item to compare constructs with different numbers of items. The standard deviations in the chart were also divided by the number of items; the error bars are not confidence intervals.

© 2025 The Author(s). Published by CV. Bimbingan Belajar Assyfa, Indonesia

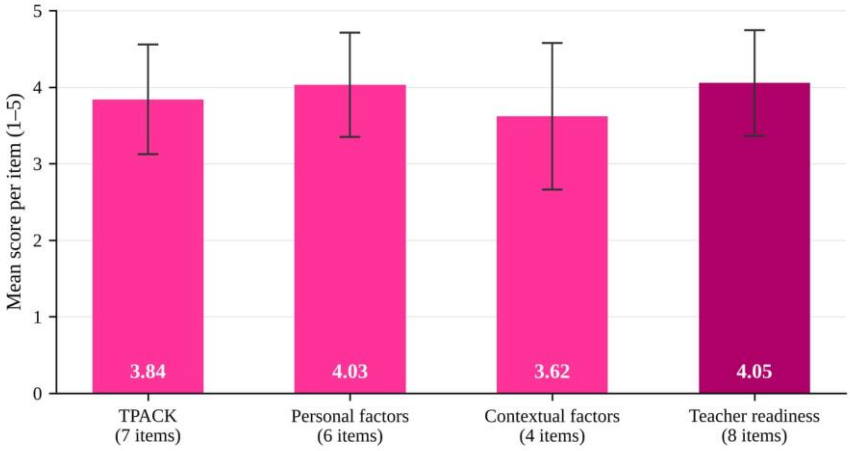


Figure 1. Mean score per item for each variable

The mean per item was calculated by dividing the total mean by the number of items used in the analysis: 3.84 for TPACK (7 items), 4.03 for personal factors (6 items), 3.62 for contextual factors (4 valid items), and 4.05 for teacher readiness (8 items). These values are arithmetic transformations of the reported descriptive statistics, not new respondent data. Variable level categories were not interpreted because the categorization thresholds and scoring rules were not adequately documented.

TPACK had a mean of 26.8750 and a standard deviation of 5.01990, with a median of 28, a minimum of 11, and a maximum of 35. This score range is consistent with seven items on a five-point Likert scale. The interpretation of TPACK in this article refers to the seven-item score reported in the validity table and descriptive statistics.

Personal factors had a mean of 24.1750 and a standard deviation of 4.08385, with a median of 25, a minimum of 9, and a maximum of 30. The six items mainly represent confidence in teaching new material, mastery of the material, keeping up with technological developments, and dealing with difficulties. The regression results show that personal factors were the only partially significant predictor. However, the survey data do not allow the direction of causality between self-belief and readiness to be determined.

Contextual factors had a mean of 14.4750 and a standard deviation of 3.83843, with a median of 15, a minimum of 6, and a maximum of 20. The validity table shows that two of the six initial items, X3.4 and X3.5, were invalid and eliminated, so the analyzed score reflects four items. The empirical maximum of 20 is therefore consistent with four items on a 1–5 scale and is not inconsistent with the initial number of items in the instrument.

Teacher readiness had a mean of 32.4250 and a standard deviation of 5.54333, with a median of 34.0000, a minimum of 12, and a maximum of 40. The readiness items cover willingness to teach electric vehicle diagnostic material, to use robotics or AI technology, to prepare learning materials, to adjust instruction to technological developments, and to face the challenges of modern learning. Because this variable was measured through self-report, the results are more accurately described

© 2025 The Author(s). Published by CV. Bimbingan Belajar Assyfa, Indonesia

as teachers' perceived or self-reported readiness rather than a direct measure of successful implementation in the classroom or workshop.

Assumption tests

The Kolmogorov–Smirnov normality test was reported to have a significance of 0.200. Because the study did not explicitly state whether the test was conducted on the regression residuals or on the variable scores, this result is presented as reported by the source and is not interpreted as full confirmation of the residual normality assumption.

For the linearity test, the relationship between TPACK and teacher readiness was reported to have a linearity component significance of < 0.01 and a deviation from linearity of 0.135. The relationship between personal factors and teacher readiness had a linearity component significance of < 0.05 and a deviation from linearity of 0.070. Both deviation from linearity values exceed 0.05, so no evidence of departure from linearity was found under the procedure used. In contrast, the relationship between contextual factors and teacher readiness was reported to have a deviation from linearity of < 0.001. This value indicates a significant departure from linear form. This result deserves attention because the subsequent model still used multiple linear regression.

Multiple linear regression

The reported regression equation is Y = 3.690 + 0.278X1 + 0.793X2 + 0.146X3. All unstandardized coefficients are positive. Holding the other predictors constant, a one-unit increase in the TPACK score is associated with an increase of 0.278 units in predicted readiness; a one-unit increase in personal factors is associated with an increase of 0.793 units; and a one-unit increase in contextual factors is associated with an increase of 0.146 units. Positive coefficients indicate the direction of the relationship in the model, but statistical significance must be judged from the partial tests and cannot be determined from the sign of the coefficient alone.

Table 3. Summary of regression results

Predictor	B	t	p	Decision at α = 0.05
TPACK (X1)	0.278	1.965	.053	Not significant
Personal factors (X2)	0.793	6.234	< .001	Significant
Contextual factors (X3)	0.146	1.036	.303	Not significant

Note: Constant = 3.690; F = 58.731, p < .001; N = 80. B = unstandardized coefficient.

The simultaneous test yielded F = 58.731 with p < .001. Thus, the null hypothesis that all predictor coefficients are simultaneously equal to zero is rejected on the basis of the reported output. This means that the model containing TPACK, personal factors, and contextual factors has a statistically significant overall relationship with teacher readiness. This simultaneous result does not mean that each predictor is individually significant. The partial tests show a different pattern: only personal factors were significant at the 5% threshold, whereas TPACK and contextual factors did not reach statistical significance.

The partial tests showed that TPACK had t = 1.965 and p = .053; personal factors had t = 6.234 and p < .001; and contextual factors had t = 1.036 and p = .303. Thus, only personal factors showed a significant partial relationship at α = 0.05.

© 2025 The Author(s). Published by CV. Bimbingan Belajar Assyfa, Indonesia

Personal factors had the largest t value and were the only partially significant predictor in the reported model. This finding indicates that personal factors provide the clearest partial statistical evidence in the study sample. However, establishing dominance as a definitive measure of relative effect requires standardized beta coefficients or comparable effect sizes together with confidence intervals; because this information was not available, the conclusion is limited to partial significance and the reported t values.

4. DISCUSSION

Descriptive profile of teacher readiness

The descriptive findings illustrate variation in TPACK, personal factors, contextual factors, and teacher readiness scores. This pattern indicates room for strengthening teachers' capacity in robotics- and AI-based electric vehicle diagnostic learning. The minimum and maximum ranges show variation among respondents, while aggregate scores do not explain which aspects are weakest for each individual. For professional development planning, the descriptive results should serve as a starting point for needs mapping rather than as the sole basis for determining training content.

TPACK and teacher readiness

TPACK emphasizes the integration of technological, pedagogical, and content knowledge. In electric vehicle diagnostic learning, teachers need to understand electric vehicle systems and safety procedures, operate diagnostic equipment, and design strategies that help students connect data with technical reasoning. The ability to operate equipment without the ability to design learning experiences is not sufficient to demonstrate pedagogical integration of technology. Yue et al. (2024) showed that TPACK readiness for AI education can reveal gaps in technological and content knowledge. This finding supports the need for targeted professional development, while taking into account differences in instruments and contexts across studies.

TPACK was not partially significant in this study's model ($p = .053$). This result is not sufficient to conclude that TPACK is unimportant for teacher readiness. First, the p value is close to the 0.05 threshold, so the result should be read as insufficient evidence under the established criterion, not as evidence that no relationship exists. Second, TPACK and personal factors may be conceptually related. When both variables are entered simultaneously, the TPACK coefficient represents its unique relationship after personal and contextual factors are taken into account. If the predictors are correlated, the unique contribution of a predictor may be smaller than its bivariate relationship. The source document did not present multicollinearity diagnostics that could be used to evaluate this possibility, so this is an agenda for further examination, not a conclusion about the cause of the result.

It is also possible that the TPACK measure used in the questionnaire captures general perceptions of the ability to integrate technology and instruction, whereas readiness to teach electric vehicle diagnosis requires more specific competencies. The analyzed TPACK items cover the use of technology, selection of methods, classroom management, mastery of material, and use of media.

© 2025 The Author(s). Published by CV. Bimbingan Belajar Assyfa, Indonesia

These items are relevant but do not necessarily measure in depth data-based diagnostic skills, interpretation of fault codes, high-voltage safety, or algorithmic reasoning. If the predictor and outcome constructs differ in conceptual proximity or level of specificity, the partial coefficients may be affected by the way they are measured. Future studies could use more detailed instruments and combine questionnaires with practical demonstrations and assessment of learning materials.

Personal factors as the clearest partial predictor

Personal factors showed a positive and significant relationship with teacher readiness ($B = 0.793$; $t = 6.234$; $p < .001$). This is the main finding of the study. The content of the instrument indicates that personal factors were measured mainly through self-efficacy, that is, teachers' belief in their ability to teach new material, understand electric vehicle diagnostics, keep up with technological developments, and overcome difficulties. Teachers who are more confident that they can learn and solve problems may be more ready to try new forms of instruction, design practical activities, and persist when facing technical obstacles. However, because personal factors were measured through six items dominated by self-belief, the term "personal factors" in this interpretation should be understood in line with that operationalization, not as encompassing all aspects of personality, motivation, experience, and personal characteristics.

This result is conceptually consistent with the study by Endot and Jamaluddin (2023), which examined antecedent factors of teacher readiness in design and technology education, and with the literature on the importance of teachers' attitudes and beliefs in technology adoption. This evidence does not mean that the relationship found in Blitar is identical to the results of other studies, as the subject context, population, and instruments may differ. The contribution of this study lies in identifying personal factors as significant when tested together with TPACK and contextual factors in the context of electric vehicle diagnostic learning. For professional development, this result provides a reason not to limit training to equipment demonstrations; programs also need to provide mastery experiences, gradual practice, feedback, mentoring, and opportunities to solve technical problems in a safe environment.

Self-efficacy development programs should remain connected to observable competencies. Training can begin with simple diagnostic tasks, such as reading parameters or fault codes on a training system, followed by data interpretation, root cause tracing, and the formulation of repair recommendations. Teachers can practice in pairs, discuss diagnostic decisions, and receive feedback from instructors or industry practitioners. Progress should be measured not only through increased confidence but also through performance rubrics, accuracy of safety procedures, quality of interpretation, and the ability to transform practical activities into learning experiences. In this way, self-belief is developed through genuine experiences of competence and is not detached from safety responsibilities.

Contextual factors and the linearity issue

Contextual factors were not partially significant in the reported model ($p = .303$). This finding needs to be interpreted carefully. A non-significant coefficient does not prove that facilities, training, school policies, or collegial support are irrelevant. Contextual variables may act as prerequisites, moderators, or factors that operate through other variables, and an aggregate measure

© 2025 The Author(s). Published by CV. Bimbingan Belajar Assyfa, Indonesia

of four valid items may not capture variation in each form of support. For example, the existence of facilities does not always mean equal access to them, and participation in training does not always reflect its quality or relevance. Institutional support may also influence opportunities for practice over the long term, whereas a cross-sectional questionnaire records perceptions at only one point in time.

Fongkanta and Buakanok (2025) reported relationships among school supportiveness, motivation to innovate, and the innovative abilities of vocational teachers in Thailand. Their findings provide a basis for viewing school support as part of an innovation ecosystem, but such support need not yield a significant partial coefficient in every population and model. The influence of school support may vary according to the availability of facilities, leadership, type of subject, and opportunities to use technology. Therefore, the results from Blitar should not be used to reduce the priority given to providing facilities or training. Instead, they suggest the need for a more specific assessment of whether the available support is actually accessible, relevant to diagnostic learning, and translated into teaching practice.

An important methodological issue is the linearity test result for contextual factors. The results show a deviation from linearity of < 0.001, indicating a significant departure from a linear pattern according to that test. If the relationship between a predictor and the outcome is not linear, the linear regression coefficient may not adequately represent the pattern of the relationship. Therefore, before concluding definitively that contextual factors are unrelated to readiness, the author needs to examine scatterplots, residual patterns, possible outliers, and model specification. Alternative analyses may be considered if supported by the data, but they should not be conducted merely to produce significance. This article retains the reported model results while flagging this assumption as a limitation that needs to be examined.

Reconciling simultaneous and partial results

The significant simultaneous test ($F = 58.731$; $p < .001$) shows that the set of predictors as a whole has a statistical relationship with teacher readiness. The simultaneous and partial results are not contradictory: a model can be significant because at least one predictor makes a sufficiently strong contribution, while other predictors are not significant after statistical control. In this study, personal factors had the largest t value and were significant, whereas TPACK and contextual factors were not. In practical terms, this result supports prioritizing the strengthening of personal aspects in training design, but not an approach that focuses solely on teachers' psychology. TPACK competence and school support remain necessary as part of the learning system, even though their partial coefficients were not significant in this sample.

Perceived versus performative readiness

The results also highlight the importance of distinguishing perceived readiness from performative readiness. All variables were collected through self-administered questionnaires, so the relationships may be affected by common method bias, social desirability, or differing interpretations of items. Teachers who rate themselves as confident may also rate themselves as ready, partly because both constructs were measured using similar response formats. Future studies should use triangulation, such as practical assessments, interviews, classroom observations, review

© 2025 The Author(s). Published by CV. Bimbingan Belajar Assyfa, Indonesia

of learning materials, or diagnostic knowledge assessments. Such data can help clarify whether personal beliefs go hand in hand with demonstrable technical ability.

Implications for teacher professional development

In terms of application, these results can be used by schools, program managers, education offices, and training providers as an initial basis for designing teacher capacity-building programs. The first stage is mapping baseline abilities that distinguish knowledge of electric vehicles, skill in using diagnostic equipment, pedagogical integration, occupational safety, and self-belief. The second stage is training based on authentic tasks involving diagnostic data or cases, not merely a general introduction to AI concepts. The third stage is post-training mentoring so that teachers can apply their competencies in the classroom or workshop. The fourth stage is performance-based evaluation to determine whether the training improves technical ability, instructional quality, and perceived readiness.

The results can also be translated into a tiered training design. The orientation stage should introduce the characteristics of electric vehicle systems, the terminology of the main components, safety principles, and the limits of diagnostic equipment use. The practice stage can focus on familiarization with scan tool or simulator interfaces, reading data, interpreting fault codes, and formulating fault hypotheses. The pedagogical stage then asks teachers to design worksheets, prompting questions, demonstrations, and assessment rubrics so that technical activities have clear learning objectives. At each stage, teachers need opportunities for repeated practice and reflection on errors without neglecting safety procedures. This sequence links increased self-efficacy with mastery of authentic tasks, so that confidence does not stand alone as a subjective perception.

Aligning readiness with safety and technical ethics

Electric vehicle diagnostic learning has a safety dimension that needs to be an explicit part of teacher readiness. Traction battery systems and high-voltage components require an understanding of hazard identification, isolation procedures, the use of protective equipment, and the limits of user competence. AI-based learning also requires data literacy, an understanding of the limitations of automated recommendations, and the habit of checking system outputs through technical reasoning. Teachers should not teach that software output is always correct or that automated diagnosis can replace professional inspection. Comprehensive readiness should include the ability to explain why a conclusion is drawn, recognize uncertainty, and decide when additional verification is needed. This aspect was not measured in detail in the source instrument and can be developed in subsequent studies.

Toward more comprehensive measurement of readiness

Future studies can improve measurement by separating at least four dimensions: conceptual knowledge, technical skills, pedagogical integration, and psychological readiness. Knowledge can be measured through case-based tests; technical skills through structured observation; pedagogical integration through assessment of lesson plans or teaching videos; and psychological readiness can still be measured through a validated self-efficacy scale. Such separation would help avoid concluding that a general readiness score represents all dimensions with equal accuracy. Stronger construct validation could also examine whether the personal factor items consistently measure

© 2025 The Author(s). Published by CV. Bimbingan Belajar Assyfa, Indonesia

self-efficacy and whether contextual factors should be divided into facilities, training, leadership, and professional collaboration.

Developing future research models

The conceptual contribution of this article is contextual: teacher readiness for electric vehicle diagnostic learning cannot be adequately understood through a single indicator of technological competence. In the tested model, personal factors were uniquely related to readiness after TPACK and contextual factors were entered together. This finding can serve as a basis for hypotheses in further research, for example, testing whether self-efficacy mediates the relationship between training and readiness, whether school support strengthens the relationship between competence and practice, or whether experience in teaching automotive technology moderates that relationship. These hypotheses have not been tested in the present study and should be treated as research directions rather than established results.

The model in this study used three predictors and one outcome variable, so it does not yet explain the mechanisms that may link institutional support, self-belief, competence, and instructional practice. Follow-up studies can test mediation or moderation models only after an adequate theoretical basis and sample size are available. For example, training may be assumed to relate to self-efficacy through practical experience, while school support may strengthen opportunities to apply competencies in the classroom. Such models must be formulated as hypotheses to be tested, not assumed to be true on the basis of the present results. Longitudinal data collection or training evaluation designs with pre- and post-program measurement can also help assess changes in readiness over time, although causal claims still require an appropriate design.

Interpreting non-significant results proportionally

Partially non-significant results are often misinterpreted as evidence that a factor is entirely irrelevant. Statistically, a non-significant decision indicates that the data and model used have not provided sufficient evidence to reject the null hypothesis at the chosen threshold. This conclusion can be influenced by sample size, score variation, measurement precision, correlations among predictors, and the assumed form of the relationship. Therefore, $p = .053$ for TPACK must not be rounded or reframed as significant, while $p = .303$ for contextual factors must not be interpreted as evidence that school support is unnecessary. Proportional reporting distinguishes statistical results, relevant theory, and practical implications, and leaves room for replication and better measurement.

Local context, generalizability, and limitations

The research location provides contextual value because it highlights the readiness of TKRO teachers in Blitar Regency and Blitar City, but it also limits generalizability. School characteristics, access to electric vehicles, availability of industry partners, teacher experience, and priorities for skill development may differ across regions. The results therefore cannot be directly assumed to represent all automotive teachers in East Java or Indonesia. Replication in regions with different levels of technological access would help test the stability of the relationship patterns. Multi-region studies could also compare school contexts with different practical facilities, but such comparisons need to use comparable sampling procedures and instruments. For local policymakers, these

© 2025 The Author(s). Published by CV. Bimbingan Belajar Assyfa, Indonesia

findings are most appropriately used as an initial diagnosis to be combined with facility audits and direct competency assessments.

The limitations of this study include its geographical scope in Blitar Regency and Blitar City, a single-period survey design, self-report measurement, and the use of linear regression even though the linearity test indicated a departure for contextual factors. The results should be interpreted as statistical associations and cannot be directly generalized to all automotive teachers in other regions.

5. CONCLUSION AND SUGGESTIONS

This study described TPACK, personal factors, contextual factors, and the readiness of SMK teachers for robotics- and AI-based electric vehicle diagnostic learning in Blitar Regency and Blitar City, and tested the relationships of the three predictors with teacher readiness. Based on the reported statistics, the mean scores were 26.8750 (SD = 5.01990) for TPACK, 24.1750 (SD = 4.08385) for personal factors, 14.4750 (SD = 3.83843) for contextual factors, and 32.4250 (SD = 5.54333) for teacher readiness.

The regression model was simultaneously significant ($F = 58.731$; $p < .001$). Partially, personal factors showed a significant positive relationship with teacher readiness ($B = 0.793$; $t = 6.234$; $p < .001$). TPACK ($B = 0.278$; $t = 1.965$; $p = .053$) and contextual factors ($B = 0.146$; $t = 1.036$; $p = .303$) were not significant at the 5% level. Personal factors were therefore the partial predictor most clearly supported by the reported data. Because the study used a survey design, this conclusion describes statistical associations and does not establish cause-and-effect relationships.

The practical implication is that teacher development programs should pay attention to self-efficacy and to learning experiences that build confidence through real practice, accompanied by the strengthening of technical and pedagogical competence and institutional support. The non-significance of TPACK and contextual factors cannot be taken to mean that these aspects are unimportant. Future studies need to add assessments of actual performance, examine possible nonlinear relationships, and test more detailed models.

6. REFERENCES

Azizah, N. L., Cornelius, C., Eviyanti, A., Liansari, V., Wardani, G., & Diba, N. F. (2025). Digital innovation: Implementation of interactive teaching materials for vocational school teachers to support Merdeka Belajar and SDGs 4. *Community Empowerment, 10*(2), 236–243. https://doi.org/10.31603/ce.12263

Endot, Z., & Jamaluddin, R. (2023). Antecedent factors influencing teacher's readiness in teaching design and technology education. *Journal of Technical Education and Training, 15*(3 Special Issue), 67–78. https://doi.org/10.30880/jtet.2023.15.03.007

Erlitasari, M., Putro, S. C., & Herwanto, H. W. (2025). Hubungan vocational capability dan persepsi terhadap inovasi teknologi dengan adaptasi perubahan dunia kerja di era Revolusi Industri 4.0 pada siswa SMK [The relationship of vocational capability and perceptions of

© 2025 The Author(s). Published by CV. Bimbingan Belajar Assyfa, Indonesia

technological innovation with adaptation to changes in the world of work in the Industry 4.0 era among SMK students]. *Journal of Electrical Vocational Education and Technology*, *8*(1), 1–10. https://doi.org/10.21009/jevet.0081.01

Fongkanta, P., & Buakanok, F. S. (2025). School supportiveness and innovative abilities in vocational education: The mediating role of motivation to innovate among vocational teachers. *Frontiers in Education*, *10*, Article 1487560. https://doi.org/10.3389/feduc.2025.1487560

Hossain, M. N., Rahman, M. M., & Ramasamy, D. (2024). Artificial intelligence-driven vehicle fault diagnosis to revolutionize automotive maintenance: A review. *Computer Modeling in Engineering & Sciences*, *141*(2), 951–996. https://doi.org/10.32604/cmes.2024.056022

Kim, J. (2025). Perceptions and preparedness of K–12 educators in adopting generative AI. *Research in Learning Technology*, *33*, Article 3448. https://doi.org/10.25304/rlt.v33.3448

Klimushyn, P., Svitlychny, V., Gnusov, Y., & Onyshchenko, Y. (2025). Automotive electronics and cybersecurity: A systematic review of security attacks and countermeasures. *Cybersecurity Education Science Technique*, *4*(28), 115. https://doi.org/10.28925/2663-4023.2025.28.760

Ning, Y., Zhang, C., Xu, B., Zhou, Y., & Wijaya, T. T. (2024). Teachers' AI-TPACK: Exploring the relationship between knowledge elements. *Sustainability*, *16*(3), Article 978. https://doi.org/10.3390/su16030978

Peng, R., Abdul Razak, R., & Hajar Halili, S. (2023). Factors influencing in-service teachers' technology integration model: Innovative strategies for educational technology. *PLOS ONE*, *18*(8), e0286112. https://doi.org/10.1371/journal.pone.0286112

Suhaedin, E., Oriza, W., Ambiyar, A., & Rizal, F. (2024). Analisis dampak program pelatihan guru terhadap kualitas pengajaran di SMK [Analysis of the impact of teacher training programs on teaching quality in vocational high schools]. *Journal on Education*, *7*(1), 3629–3638. https://doi.org/10.31004/joe.v7i1.6959

Yang, X. (2024). Framework of electric vehicle fault diagnosis system based on diagnostic communication. *International Journal of Engineering, Transactions B: Applications*, *37*(6), 1194–1207. https://doi.org/10.5829/ije.2024.37.06c.16

Yue, M., Jong, M. S.-Y., & Ng, D. T. K. (2024). Understanding K–12 teachers' technological pedagogical content knowledge readiness and attitudes toward artificial intelligence education. *Education and Information Technologies*, *29*(15), 19505–19536. https://doi.org/10.1007/s10639-024-12621-2

Yuniarti, Y., & Walajro, J. (2024). Measuring the impact of principals' competence and facilities on teachers' achievement in public vocational high schools in Palembang City: A multivariate analysis. *Nusantara Journal of Behavioral and Social Sciences*, *3*(1), 25–34. https://doi.org/10.47679/202447

© 2025 The Author(s). Published by CV. Bimbingan Belajar Assyfa, Indonesia