Enhancing 21st-Century Teaching: A Study on Technology Integration in STEM Classrooms across Malaysia's Southern Zone

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ABSTRAK

Technology integration is one of the thirteen core constructs within the Sciences, Technology, Engineering, Mathematics Productive Learning (STEMPL) Practices framework, playing a crucial role in supporting meaningful, contextual, and collaborative learning experiences. This study aims to examine the level of technology integration among lower secondary STEM teachers teaching Science, Basic Computer Science (BCS), Design and Technology (DT), and Mathematics. In addition, it investigates the relationship between the level of technology integration and both the subjects taught and teaching experience. A quantitative approach with a cross-sectional survey design was employed, involving a total of 556 teachers from the southern zone states of Johor, Melaka, and Negeri Sembilan, Malaysia. The sample was selected using a multistage stratified cluster random sampling technique, beginning at the state level, followed by district and school levels. The research instrument (STEMPLQ), developed based on the 13 STEMPL constructs, was validated through Exploratory Factor Analysis (EFA) and Confirmatory Factor Analysis (CFA), and demonstrated high reliability ($\alpha = .97$). Findings revealed that the level of technology integration was at a moderately low level ($M = 3.43$, $SD = 0.59$), particularly among Mathematics and BCS teachers, as well as teachers with over 20 years of experience. A significant negative correlation was found between teaching experience and the level of technology integration. The study underscores the need for targeted training and peer mentoring to support effective STEMPL integration. A broader construct of technology integration, including higher-order pedagogies and contextual factors such as digital readiness and teacher self-efficacy, is essential for a more comprehensive understanding of implementation challenges.

Keywords: technology integration, STEMPL practices, meaningful learning, More Knowledgeable Others

INTRODUCTION

Entering the 21st century, the fields of Science, Technology, Engineering, and Mathematics (STEM) have received increasing attention in national development agendas, including in Malaysia (Chua & Choong, 2020). The rise of STEM has accelerated economic, social, and technological activities, thereby transforming the employment landscape in profound ways (Ong et al., 2017). According to the World Economic Forum (2018), 65% of primary school students today are expected to work in future careers that are yet to exist, most of which are likely to be STEM-related. In this context, the younger generation must be equipped with advanced knowledge, skills, and values in STEM to navigate increasingly complex global challenges.

In response to these evolving demands, traditional teaching approaches have increasingly been deemed inadequate. There is an urgent need for innovative pedagogical practices that prioritise critical thinking, problem-solving, and digital fluency. Recognising this need, the Ministry of Education Malaysia (MOE) introduced the Malaysia Education Blueprint (2013–2025) which highlights the transformation of STEM education through integrated and holistic strategies (MOE, 2013). As argued by Faizah and Ruhizan (2022), further assert that meaningful STEM learning should involve the integration of multiple disciplines within authentic, real-world contexts.

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In line with this direction, the STEM Productive Learning Practices framework (STEMPL) was developed, encompassing thirteen core constructs to support impactful STEM teaching and learning practices. Among the critical elements identified is the integration of technology in STEM pedagogy. Technology integration not only enhances content delivery by making it more interactive and engaging but also enriches students' learning experiences by providing access to authentic and contextual digital resources. In the era of the Fourth Industrial Revolution, digital technology serves as a catalyst for 21st-century pedagogy, making it imperative for teachers to develop competence in integrating technology (Sionti et al., 2018).

Despite this, there remains a significant gap in technology integration competencies among teachers. Sionti et al. (2018) describe most teachers as "digital migrants" who struggle to adapt to rapidly evolving digital environments, while their students, often described as "digital natives", are immersed in technology in their everyday lives. This imbalance presents a major challenge in the effective implementation of modern, technology-enhanced teaching approaches (Odell et al., 2019). This highlights the need for empirical studies to assess teachers' digital integration levels and inform targeted professional development initiatives

Although various national initiatives have been introduced, there appears to be a lack of consistency in the implementation of technology integration among teachers, especially STEM teachers. Local studies suggest that despite increasing access to technological infrastructure, the actual use of technology in teaching and learning remains limited and is seldom employed to support meaningful learning (Rahmat et al., 2021; Rajendram, 2022). This raises critical questions about whether factors such as teaching experience and subject specialisation influence the level of technology integration. This raises crucial questions about the influence of teacher-specific factors—such as subject specialisation and teaching experience on technology integration.

From the lens of Vygotsky Social Constructivist Theory (1978), the teacher functions as a More Knowledgeable Other (MKO) who scaffolds student learning within the Zone of Proximal Development (ZPD). In this context, teachers are not merely content deliverers, but facilitators of digital learning experiences—guiding students in constructing knowledge through authentic technology use (Azlina et al., 2018; Daly-Smith et al., 2021). Without proper identification and development of teachers' competencies, however, efforts such as NDEP and STEMPL risk falling short of their intended impact.

Nonetheless, without systematic identification and enhancement of teachers' technological integration practices, the implementation of the National Digital Education Policy (NDEP) is likely to face considerable challenges (MOE, 2023). This shortfall could undermine the effectiveness of teaching and learning processes and diminish the potential value of technology in enhancing student learning outcomes (Rahmat et al., 2021). With the rapid advancement of Artificial Intelligence (AI), it is becoming increasingly critical for teachers as MKOs, to be technologically literate to create learning environments that are relevant, contextual, and aligned with contemporary realities.

Recent studies by Kong and Mohd Effendi (2020) and Hanifah et al. (2023) demonstrate that platforms like Google Classroom, Microsoft Teams, Kahoot!, Scratch, and GeoGebra have enhanced students' learning experiences, especially in visualising abstract concepts and promoting interactivity. However, research linking the use of these tools directly with STEMPL-based teaching remains limited. The role of the teacher as MKO empowered with both pedagogical knowledge and technological proficiency is essential in leveraging these tools to foster meaningful, future-ready learning.

The successful implementation of both the NDEP and STEMPL relies heavily on teachers' capacity to integrate technology meaningfully and to embody the role of MKOs. Therefore, examining the current state of technology integration among teachers is essential to ensure their readiness to strengthen digital learning practices and cultivate future-ready human capital.

Despite various efforts, empirical studies that directly link Productive Learning Practices with the level of technology integration among STEM teachers in Malaysia remain limited. There exists a significant literature gap concerning how STEMPL is operationalised to support effective technology integration, particularly in subjects such as Science, BCS, DT and Mathematics (Cole et al., 2018; Kong & Mohd Effendi, 2020a; Odell et al., 2019). Prior research by Daly-Smith et al. (2021), Hanifah et al. (2023), and Rahmat et al. (2021) has predominantly focused on infrastructure and teachers' digital skills, with limited emphasis on student-centred pedagogical approaches advocated within the STEMPL framework.

Besides policy and teacher roles, subject matter also plays a significant role in determining the level of technology integration in teaching and learning. Subjects such as BCS and DT inherently require the use of technological tools including programming software, design applications, and digital simulation tools (Kelly et al., 2019). In contrast, technology use in Science and Mathematics often depends on the pedagogical strategies employed by teachers and their ability to align technology with lesson content and objectives (Zhao et al., 2023).

Additionally, teaching experience influences the variation in technology integration practices. While experienced teachers may possess robust pedagogical knowledge, they may face challenges with digital proficiency. Conversely, younger teachers who are more technologically adept may lack exposure to effective instructional strategies (Aqib et al., 2025). This creates an imbalance in the implementation of technology-enhanced instruction, particularly in STEM subjects.

Although multiple national efforts have aimed to strengthen technology use in education, the need for empirical investigation that links STEMPL with the actual level of technology integration remains pressing. There is a clear gap in how STEMPL is applied as a comprehensive, student-centred pedagogical framework to support effective digital integration in lower secondary STEM classrooms particularly in Science, BCS, DT and Mathematics, which are key feeder subjects into STEM education pathways.

METHODOLOGY

This study employed a quantitative approach with a cross-sectional survey design to assess the practice of technology integration among teachers. The primary research instrument used was the STEM Productive Learning Practices Questionnaire (STEMPLQ), which was systematically developed and demonstrated high validity and reliability in measuring the intended constructs. Technology integration was one of the 13 core elements constituting the STEMPL construct.

Based on data obtained from the State Education Departments of the southern zone states of Peninsular Malaysia, comprising Negeri Sembilan, Melaka, and Johor, these states were identified as regions with relatively low student enrolment in STEM streams compared to the national average. The selection of these states was also based on considerations of administrative feasibility in terms of time and cost efficiency. The study population comprised 6,786 lower secondary school teachers who taught STEM subjects, namely Science, BCS, DT and Mathematics across the three states.

Sample size determination was guided by the recommendations of Krejcie and Morgan (1970) and The Research Advisors (2006), which propose a minimum sample of 360 for a population of this size. However, Creswell (2018) suggests increasing the sample size by at least 10% to accommodate potential issues such as outliers and missing values. Accordingly, this study set a minimum sample size of 400 teachers.

A multistage random sampling method was employed, integrating both cluster and stratified sampling techniques to ensure representativeness and homogeneity of the sample. Initially, cluster sampling was conducted based on the three selected states in the southern zone, which differ in terms of district and school distribution. Subsequently, schools were selected from each district. At the school level, stratified sampling was implemented by stratifying teachers according to gender, in alignment with the actual demographic distribution of STEM teachers. Respondent selection was based on a 3:7 male-to-female ratio, reflecting the actual gender composition of the teaching workforce. Data collection was conducted online using Google Forms, distributed through official school email addresses. This approach aligns with the recommendations of Couper, (2000), who highlighted the effectiveness of digital survey distribution in reaching respondents across a wide geographical area, especially for large-scale studies.

The STEMPLQ instrument was developed through a systematic meta-analysis of 32 peer-reviewed articles relevant to STEM education in the Malaysian context. Its development was informed by instrument construction models proposed by Du Plessis and Martins (2019) and Miller and Lovler (2018). The development process involved three major phases: conceptualisation, instrument construction, and validation, all guided by a systematically developed conceptual framework.

The instrument consists of Section A, which gathers demographic information using nominal scales (for subject taught) and ordinal scales (for teaching experience). Section B contains items related to teachers' practices in STEMPL, measured using an affective-domain Likert-type scale, as suggested by Coolican (2019) and Miller and Lovler (2018). The Likert-type scale allows for the assessment of respondents' agreement levels on each item, thus providing a more nuanced understanding of their STEMPL practices.

To ensure high validity and reliability, rigorous psychometric analyses were conducted. Content validity was established using Fleiss' Kappa and the Content Validity Index (CVI). The analyses indicated high index values, confirming expert consensus that the instrument appropriately represents the content domains relevant to technology integration in Malaysian STEM education (Fleiss et al., 1982; Polit et al., 2007). Construct validity was assessed using both Exploratory Factor Analysis (EFA) and Confirmatory Factor Analysis (CFA). EFA validated that the 13 theoretically developed elements aligned with the empirical dimensions of the data, while CFA confirmed that the measurement model fit the data adequately (CMIN/df = 2.60; RMSEA = 0.06), in accordance with the recommendations of Hair et al. (2019) and Kline (2005). Discriminant validity was also demonstrated, based on the criteria proposed by Joreskog (1971), affirming that the constructs are related but distinct.

Reliability analysis was conducted to assess the internal consistency of the instrument. Cronbach's alpha for the 62 items in the questionnaire yielded a value of 0.97, which meets the threshold recommended by DeVellis (2016) for social science research instruments.

In this study, Technology Integration Practice was identified as one of the thirteen core elements underpinning the STEMPL construct. Based on the results of Exploratory Factor Analysis (EFA) and Confirmatory Factor Analysis (CFA), four out of seven items developed for this construct met the required model fit thresholds. These retained items were found to validly and reliably measure the construct, in alignment with the conceptual and empirical dimensions of the STEMPL framework.

As shown in Table 1, all retained items demonstrated satisfactory factor loadings (≥ 0.60), consistent with the threshold recommended by Collier (2020) for newly developed measurement instruments.

Table 1: Items Under the Technology Integration Practice Element that Met the Model Fit Criteria for the STEMPL Framework

Item code	Item statement	Factor Loading	Remarks
TI1	I utilise MS Teams / Google Classroom to assign tasks related to STEM topics for students to complete independently	0.63	Retained – meets model fit criteria
TI2	I schedule online group presentations using applications such as Zoom, Google Meet, or MS Teams for STEM-related assignments.	0.65	Retained – meets model fit criteria
TI3	I conduct online critique sessions using applications to develop students' critical thinking on STEM assignments.	0.66	Retained – meets model fit criteria
TI4	I share current STEM-related issues through files, videos, animations, or diagrams using online platforms to optimise student engagement.	0.68	Retained–meets model fit criteria

Although the loadings did not exceed 0.70, they were considered acceptable given the exploratory nature of the instrument and the novelty of the construct in the local context (Collier, 2020; Hair et al., 2019). As such, these items were maintained in the final measurement model, which demonstrated satisfactory overall model fit.

For field data collection, this study employed Google Forms as the platform for distributing the online questionnaire, in line with recommendations from the Educational Policy Planning and Research Division (EPRD). This method was chosen due to its ability to reach the target population broadly and efficiently, particularly for studies involving respondents across multiple districts. A total of 665 responses were successfully obtained from 21 districts across the southern zone states. However, following a thorough data cleaning process to detect and remove outliers and missing values, 556 responses were validated and retained for subsequent analysis.

In terms of respondent demographics, 145 teachers (26%) were male, while 411 teachers (74%) were female. The application of simple random sampling principles ensured that the obtained sample was sufficiently representative in terms of homogeneity and regional distribution, which aligns with the requirements of quantitative research that emphasises adequate sample size and representativeness for generalisation purposes.

Once data collection was completed, preliminary data analysis was conducted using the Statistical Package for the Social Sciences (SPSS) version 26. A normality test was performed as an initial procedure to determine the most appropriate statistical analyses to be employed. While Coolican (2019) suggests that categorical (nominal) data are more suited to non-parametric testing, the normality assessment for the continuous variables in this study revealed that the distribution of data for the technology integration variable was normal when examined across teaching experience and subject taught. This conclusion was drawn based on skewness and kurtosis values, which indicated that the data were within acceptable ranges for parametric analysis.

Accordingly, the study employed parametric tests, specifically the Pearson Product-Moment Correlation, to examine the relationships between variables. This test was selected for its ability to measure both the strength and direction of linear relationships between variables measured at interval and ratio levels. The test was deemed appropriate for the study’s objective of identifying the association between teachers’ technology integration practices in STEMPL and two factors: years of teaching experience and STEM subjects taught.

FINDINGS

The research findings are presented based on the following components: respondent demographics, the general norms and profile of overall STEMPL practise framework, the level of technology integration among STEM teachers, and the relationships between technology integration and two key factors, subjects taught and teaching experience. Each aspect is elaborated in detail as follows:

Demography

The study sample consisted of STEM teachers who taught Science, BCS, DT, and Mathematics at the lower secondary level. A multistage sampling technique, incorporating cluster and stratified random sampling, was employed to ensure representation across diverse districts in the southern zone, Malaysia. Initially, a total of 665 responses were collected. A rigorous data cleaning process was subsequently conducted, during which 109 responses were removed due to the presence of outliers and missing values. The final dataset consisted of 556 valid responses, which were confirmed to meet the criteria for representativeness and homogeneity across the targeted districts in the southern zone. The teaching experience factor was divided into five groups, namely: teachers with 0 to 5 years, 6 to 10 years, 11 to 15 years, 16 to 20 years, and more than 20 years of teaching experience. Meanwhile, the subject taught factor was categorised into four groups, namely: Science, BCS, TD, and Mathematics teachers. Table 2 presents the sample analysis based on the teaching experience factor and the subject taught.

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Table 2: Analysis Based on Teaching Experience and Subjects Taught Factors

Demographic Factors	Type	Total	Percentage
Teaching Experience	0-5 Year	53	9.5
	6 - 10 Year	94	16.9
	11- 15 Year	176	31.7
	16-20 Year	106	19.1
	More than 20 Year	127	22.8
Subjects Taught	Science	181	32.4
	BCS	54	9.7
	TD	128	22.9
	Mathematics	193	34.7

As shown in Table 2, a total of 53 teachers (9.5%) had 0–5 years of teaching experience, while 94 teachers (16.9%) had 6–10 years of experience. Additionally, 176 teachers (31.7%) had 11–15 years of experience, and 106 teachers (19.1%) had been teaching for 16–20 years. A total of 127 teachers (22.8%) had more than 20 years of teaching experience.

In terms of subject taught, 181 teachers (32.4%) taught Science, 54 teachers (9.7%) taught BCS, 128 teachers (22.9%) taught DT, and 193 teachers (34.7%) taught Mathematics.

Norms and Profiles of Stem Productive Learning Practice Levels

In studies that examine the level of technology integration among teachers, it is essential to first establish the norms and teacher profiles for STEM Productive Learning Practices (STEMPL) before determining their level of technology integration. According to Miller and Lovler (2018), this approach ensures the accuracy of data analysis and contributes to a better understanding of the factors influencing technology integration in teaching.

Kaplan and Saccuzzo (2018) and Coolican (2019) highlight that teacher norms and profiles serve as standard references for assessing overall levels of productive STEM learning practices. By establishing these norms beforehand, researchers can objectively determine the position of teachers' technology integration levels within the broader population. Teacher profiles, including teaching experience, subject taught, and readiness to implement STEM play a crucial role in understanding the extent to which teachers are capable of integrating technology into their instructional practices. Having access to this information enables researchers to identify potential relationships between STEMPL practices and levels of technology integration. This also facilitates meaningful comparisons to determine whether technology integration is high, moderate, or low within the population studied. Without clearly defined norms, any interpretation of the integration level may lack precision, thereby complicating the analysis and discussion of research findings.

The level of teachers' STEMPL practices was categorised based on the mean scores obtained, following the normal distribution guidelines proposed by Coolican (2019) and Kline (2005). Meanwhile, the interpretation of each level was based on the Dreyfus Model (2004), which was adapted into six categories: Very Low (2.33 to 2.74), Low (2.75 to 3.18), Moderately Low (3.19 to 3.58), Moderately High (3.59 to 4.01), High (4.02 to 4.43), and Very High (4.44 to 4.85).

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An analysis of STEM teachers' STEMPL practice levels was conducted based on the dimensions and elements investigated. The findings revealed that the Teaching Plan dimension (M = 3.54, SD = 0.43) and 21st Century Learning-Oriented TBCSs (M = 3.50, SD = 0.46) were categorised as moderately low. In contrast, the Higher Order Thinking Skills (HOTS) dimension (M = 3.69, SD = 0.41) was classified as moderately high.

However, five out of the thirteen elements examined were found to be at a moderately low level, namely: Learning Objectives (M = 3.46, SD = 0.52), Assessment Methods (M = 3.36, SD = 0.50), Lesson Closure (M = 3.44, SD = 0.51), Problem Solving (M = 3.29, SD = 0.54), and Technology Integration (M = 3.43, SD = 0.59).

Overall, the level of teachers' STEMPL practices was categorised as moderately high, with a total mean score of 3.59 (SD = 0.42). Meanwhile, the level of Technology Integration was classified as moderately low, with a mean score of 3.43 (SD = 0.59). A detailed analysis of the study's findings is presented in Table 3.

Table 3: Teacher's STEMPL Practice Level

Dimensions / Elements	Min	SD	Definition
Lesson Plan	3.54	0.43	Medium Low
Induction Set	3.77	0.47	Medium High
Learning Objectives	3.46	0.52	Medium Low
Content Development	3.65	0.49	Medium High
Assessment Method	3.36	0.50	Medium Low
Closure	3.44	0.51	Medium High
HOT	3.69	0.41	Medium High
Oral Questioning	3.63	0.47	Medium High
Written Questioning	3.61	0.47	Medium High
Inductive Methods	3.72	0.46	Medium High
Deductive Method	3.82	0.45	Medium High
PAK-21 Oriented Assignments	3.50	0.46	Medium Low
Knowledge Transfer	3.64	0.48	Medium High
Critical Thinking	3.64	0.48	Medium High
Problem Solving	3.29	0.54	Medium Low
Technology Integration	3.43	0.59	Medium Low
STEM Productive Learning	3.59	0.42	Medium High

In conclusion, these findings suggest that the use of technology in teaching has not yet been fully optimized. In addition, the level of Technology Integration (M = 3.43, SD = 0.59) was also lower than the mean value of the teacher's overall STEMPL practice, which was 3.59 (M = 3.59, SD = 0.42).

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Level of Technology Integration Among Stem Teachers

To address the first research question, the level of Technology Integration among STEM teachers was analysed based on the relevant dimensions and elements. According to the established norms, the overall level of technology integration among STEM teachers was categorised as moderately low, with a mean score of 3.43 (M = 3.43, SD = 0.59).

Analysis based on the subject taught revealed that teachers of BCS (M = 3.39, SD = 0.66) and Mathematics (M = 3.23, SD = 0.63) recorded the lowest mean scores, both of which fall within the moderately low category.

In addition, analysis by the teaching experience demographic factor indicated a declining trend in mean scores as teaching experience increased. Teachers with more than 20 years of experience recorded the lowest mean score, at M = 3.33. These findings are summarised in Table 4.

Table 4: Levels of Technology Integration among STEM Teachers

Demography	Min	SD	Definition
Subjects Taught			
Science	3.55	0.49	Medium Low
BCS	3.39	0.66	Medium Low
TD	3.55	0.53	Medium Low
Mathematics	3.23	0.63	Medium Low
Teaching Experience			
0-5 years	3.52	0.57	Medium Low
6-10 years	3.53	0.58	Medium Low
11-15 years	3.46	0.58	Medium Low
16-20 years	3.35	0.55	Medium Low
Over 20 years	3.33	0.62	Medium Low
Technology Integration	3.43	0.59	Medium Low

There is a clear need to enhance technology training, particularly for more experienced teachers as well as those teaching BCS and Mathematics. Strategic measures such as intensive training, the integration of technology into pedagogy, and improved access to digital resources should be considered to strengthen the implementation of technology integration in STEM teaching.

Relationship Between Technology Integration and the Factors of Subject Taught and Teaching Experience

An analysis was conducted to examine the relationship between technology integration and the variables of subject taught and teaching experience. The subject taught variable was coded as nominal data (1 = Science, 2 = Basic Computer Science [BCS], 3 = Design and Technology [DT], 4 = Mathematics), while the teaching experience variable was coded as ordinal data (1 = 0–5 years, 2 = 6–10 years, 3 = 11–15 years, 4 = 16–20 years, 5 = more than 20 years).

According to Coolican (2019), it is recommended that the normality of such data be assessed using both skewness and kurtosis. Based on this evaluation, both variables were determined to be non-parametric in nature. This is in line with the suggestion by Nanna and Sawilowsky 1998), who emphasized that data must first be assessed to determine whether it meets the assumptions for parametric or non-parametric analysis, in order to select the most appropriate statistical test.

To examine the relationship between technology integration and the subject taught, the Spearman's rho test was employed. Meanwhile, the Kruskal–Wallis's test was used to analyse differences in technology integration based on teaching experience, as this variable is an ordinal-level independent variable.

The findings on the relationship between technology integration and the subject taught are presented in Table 5.

Table 5: Spearman's Rho Test for the Relationship Between Technology Integration and Subject Taught

			Technology Integration	**Subjects**
Spearman's rho	Technology Integration	Correlation coefficient	1.000	-.194**
		Sig. (2-tailed)	.	.000
		N	556	556
	Subjects	Correlation coefficient	-.194**	1.000
		Sig. (2-tailed)	.000	.
		N	556	556
**. Correlation is significant at the 0.01 level (2-tailed).				

Table 5 presents the results of the analysis examining the relationship between technology integration and the subject taught. A weak but statistically significant negative correlation was found ($r = -.19$, $p < .05$). This finding indicates that there is a significant inverse relationship between the subject taught and the level of technology integration, suggesting that certain subjects are associated with lower levels of technology use in instructional practices.

Subsequently, the Kruskal–Wallis's test was conducted to examine the relationship between technology integration and teaching experience. The results of this analysis are summarised in Table 6.

Table 6: Kruskal-Wallis Test

	Teaching Experience	N	Mean Rank
Technology Integration	0-5 years (N_1)	53	307.44
	6-10 years (N_2)	94	306.58
	11-15 years (N_3)	176	287.24
	16-20 years (N_4)	106	256.72
	over 20 years (N_5)	127	251.70
	Total	556	

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Kruskal-Wallis H	10.79
df	4
Asymp. Sig. (*p*)	0.03

The Kruskal–Wallis's test was conducted to determine whether there were significant differences in technology integration practices among STEM teachers based on their years of teaching experience. The analysis yielded a statistically significant result, with H = 10.79, p = .03. The p-value obtained is lower than the standard level of significance ($\alpha = .05$) as recommended by Corder and Foreman (2014), indicating that the null hypothesis can be rejected.

To determine the strength of the effect, effect size was calculated using eta squared (η^2), based on the formula $\eta^2 = H / (N - 1)$. The calculated eta squared value was 0.02, suggesting a small effect size, in accordance with the benchmarks proposed by Cohen and Swerdlik (2009).

In summary, the Kruskal–Wallis's test revealed that there is a statistically significant but weak relationship (H = 10.79, p = .03, $\eta^2 = 0.02$) between technology integration practices and teaching experience among STEM teachers. This finding suggests that teaching experience has some influence, albeit limited, on the degree to which teachers integrate technology in STEM instruction.

DISCUSSION

The findings indicate that the overall level of technology integration among STEM teachers is categorised as moderately low, with a mean score of M = 3.43 (SD = 0.59). This suggests that the use of technology in STEM instruction has not yet been optimally implemented, particularly in the subjects of BCS (M = 3.39, SD = 0.66) and Mathematics (M = 3.23, SD = 0.63), which recorded the lowest mean scores.

Studies by Dangi et al. (2023) and Uchima-Marin et al. (2024) have identified key barriers to technology integration, including a lack of targeted training, limited access to technological infrastructure, and teachers' beliefs or attitudes towards the effectiveness of technology in enhancing learning. In the context of BCS and Mathematics, the integration of technology-enhanced learning environments, such as mathematical simulations and data analysis software, is crucial to promote higher-order thinking skills among students.

Kong and Mohd Effendi (2020) emphasised that problem-based learning (PBL) supported by technology can significantly enhance critical thinking and problem-solving skills in STEM education. Likewise, Rehman et al. (2025) stressed the importance of contextualised professional development programmes tailored to teachers' needs, particularly for those teaching subjects with lower levels of technology integration. These programmes should include hands-on training with emerging technologies, with a specific focus on BCS and Mathematics.

Furthermore, the analysis based on the teaching experience demographic revealed a declining trend in technology integration as years of experience increased. Teachers with more than 20 years of experience recorded the lowest mean score (M = 3.33). The Kruskal–Wallis's test confirmed a statistically significant but weak relationship between teaching experience and technology integration (H = 10.79, p = .03). Additionally, Spearman's rho correlation showed a significant but weak negative correlation between technology integration and the subject taught ($r = -0.19$, $p < .05$).

These findings are consistent with the study by Gunobgunob-Mirasol (2024), which reported that more experienced teachers are generally less inclined to adopt technology due to limited exposure to emerging digital tools. Similarly, Nurul Shahhida et al. (2020), through the Technological Pedagogical Content Knowledge (TPACK) model, emphasised that effective technology integration necessitates a dynamic and holistic interplay between content expertise, pedagogical knowledge, and technological proficiency.

Supporting this view, Jailani and Nasri (2024) found that senior teachers tend to rely on conventional instructional approaches and often experience difficulties in adapting to newer technologies. Consequently, ongoing support and mentoring through Professional Learning Communities (PLCs) plays a critical role in enabling teachers to share best practices and collaboratively address challenges. Boz (2023) highlighted that continuous coaching significantly improves teachers' confidence in using technology.

An emerging and promising strategy involves reverse-mentoring, where digitally savvy novice teachers serve as More Knowledgeable Others (MKO), to support senior colleagues in technology adoption (Gunobgunob-Mirasol, 2024). Given that teachers with more than 20 years of experience demonstrated the lowest levels of technology integration, Wu et al. (2024) proposed that training programmes should emphasise contextual relevance and provide additional support mechanisms to build confidence and technological competencies among senior educators.

CONCLUSION

To advance future research and educational practice, it is imperative that the conceptualisation of technology integration be broadened to include higher-order digital pedagogies, such as simulation-based inquiry, collaborative design-based tasks, and data-driven exploration in STEM learning. These pedagogical strategies are not only consistent with the tenets of 21st-century education but are also fundamentally aligned with the learner-centred and inquiry-oriented principles embedded within the STEMPL framework.

In addition, a more nuanced and multi-dimensional understanding of technology integration can be achieved by incorporating relevant contextual variables, including the level of school digital readiness, the availability and reliability of ICT infrastructure, institutional leadership support, and teachers' access to sustained and context-sensitive professional development opportunities. These variables are likely to moderate or mediate the effectiveness of technology integration efforts and should therefore be central considerations in both policy design and empirical investigation.

The findings of this study also highlight the pivotal role of systemic stakeholders including Ministry of Education (MOE), District Education Offices (PPD), and school leadership teams in driving coherent and strategic professional development initiatives that prioritise technology enhanced pedagogies. Without a unified, top-down and bottom-up approach, the disparities and inconsistencies in technology integration practices across schools may persist, thus impeding the broader educational reform agenda towards future-ready, digitally competent learners.

Finally, greater attention must be given to teachers' digital self-efficacy, pedagogical beliefs, and attitudes towards technology, as these internal factors significantly influence the translation of technological affordances into meaningful instructional practices. Addressing these psychological and behavioural dimensions can inform the development of more targeted, personalised, and sustainable intervention models, thereby enhance the fidelity of policy implementation and ensuring stronger alignment between national aspirations and classroom realities in Malaysian STEM education.

REFERENCES

1. Aqib, M. A., Ekawati, R., & Khabibah, S. (2025). A modified technological pedagogical and content knowledge (TPACK) framework: A systematic literature review. Multidisciplinary Reviews, 8(6). https://doi.org/10.31893/multirev.2025167
2. Azlina, A. R., Norasyikin, M. Z., Baharuddin, A., Zaleha, A., Hasnah, M., & Henny, V. D. M. (2017). Implementation strategy of project based learning through flipped classroom method. 2016 IEEE Conference on E-Learning, e-Management and e-Services, IC3e 2016, 1–5. https://doi.org/10.1109/IC3e.2016.8009030
3. Boz, T. (2023). Teacher Professional Development for STEM Integration in Elementary/ Primary Schools: A Systematic Review. International Electronic Journal of Elementary Education, 15(5), 371–382. https://doi.org/10.26822/iejee.2023.306
4. Chua, Y. L., & Choong, P. Y. (2020). Interactive STEM Talk and Workshop Outreach Programme-By Students , for Students : A Malaysian Context. 182–186.
5. Cohen, R. J., & Swerdlik, M. E. (2009). Psychological Testing and Assessment: An Introduction to Tests

and Measurement, Seventh Edition.

6. Cole, R., Lantz, J. M., Ruder, S., Reynders, G. J., & Stanford, C. (2018). Enhancing learning by assessing more than content knowledge. ASEE Annual Conference and Exposition, Conference Proceedings, 2018-June.
7. Collier, J. E. (2020). Applied Structural Equation Modelling Using AMOS : Basic to Advanced Techniques. In Applied Structural Equation Modelling for Researchers and Practitioners. Routledge. https://doi.org/10.1108/978-1-78635-883-720161025
8. Coolican, H. (2019). Research Methods and Statistics in Psychology (Seven Edit). Psychology Press.
9. Corder, W. G., & Foreman, I. D. (2014). Nonparametric statistics: A step-by-step approach. John Wiley & Sons, Inc., Hoboken, New Jersey.
10. Couper, M. P. (2000). Web Surveys: A Riview Of Issues And Approaches. In American Association for Public Opinion Research (Vol. 64, Issue 4, pp. 464–494).
11. Creswell, J. W. (2018). Research Design : Qualitative, Quantitative, and Mixed Method Approaches Fifth Edition (Fifth Edit). Sage Publication.
12. Daly-Smith, A., Morris, J. L., Norris, E., Williams, T. L., Archbold, V., Kallio, J., Tammelin, T. H., Singh, A., Mota, J., von Seelen, J., Pesce, C., Salmon, J., McKay, H., Bartholomew, J., & Resaland, G. K. (2021). Behaviours that prompt primary school teachers to adopt and implement physically active learning: a meta synthesis of qualitative evidence. International Journal of Behavioral Nutrition and Physical Activity, 18(1), 1–20. https://doi.org/10.1186/s12966-021-01221-9
13. Dangi, M. R. M., Saat, M. M., & Saad, S. (2023). Teaching and learning using 21st century educational technology in accounting education: Evidence and conceptualisation of usage behaviour. Australasian Journal of Educational Technology, 39(1), 19–38. https://doi.org/10.14742/ajet.6630
14. DeVellis, R. F. (2016). Scale Development Theory and Applications (Fourth Edition). SAGE Publication, 4, 256.
15. Du Plessis, M., & Martins, N. (2019). Developing a measurement instrument for coping with occupational stress in academia. SA Journal of Industrial Psychology, 45, 1–13. https://doi.org/10.4102/sajip.v45i0.1653
16. Faizah, A. W., & Ruhizan, M. Y. (2022). Kepimpinan Pengajaran dalam Merealisasikan STEM Bersepadu. Malaysian Journal of Social Sciences and Humanities (MJSSH), 7(4), e001435. https://doi.org/10.47405/mjssh.v7i4.1435
17. Fleiss, J. L., Levin, B., & Paik, M. C. (1982). Statistical Methods for Rates and Proportions. In Journal of the Royal Statistical Society. Series A (General) (Third Edit, Vol. 145, Issue 4). Wiley-Interscience. https://doi.org/10.2307/2982107
18. Gunobgunob-Mirasol, R. (2024). Literacy in Pandemic: Practices, Challenges, and Coping Strategies of MKO's in Online and Modular Learning Modalities. International Journal of Education and Literacy Studies, 12(2), 181–190. https://doi.org/10.7575/aiac.ijels.v.12n.2p.181
19. Hair, J. F., Black, W. C., Babin, B. J., & Anderson, R. E. (2019). MULTIVARIATE DATA ANALYSIS (Eight Edit). Cengage Learning, EMEA.
20. Hanifah, S. S. A., Ghazali, N., Ayub, A. F. M., & Roslan, R. (2023). Predicting teachers' use of digital technology. International Journal of Evaluation and Research in Education, 12(2), 555–562. https://doi.org/10.11591/ijere.v12i2.24237
21. Jailani, N., & Nasri, N. M. (2024). Pembelajaran Berasaskan Komuniti dalam Pendidikan STEM Sekolah Menengah di Malaysia : Sorotan Literatur Sistematik (Community-based Learning in Secondary School STEM Education in Malaysia : A Systematic Literature Review). 9(11).
22. Joreskog, K. . (1971). STATISTICAL ANALYSIS OF SETS OF CONGENERIC TESTS. British Dental Journal, 36(2), 33–36. https://doi.org/10.1038/sj.bdj.4802691
23. Kaplan, M. R., & Saccuzzo, P. D. (2018). Psychological testing; principles, applications, & issues, Ninth editon. (2017). In Australian Journal of Politics and History (Vol. 65, Issue 2). https://doi.org/10.1111/ajph.12576
24. Kelly, N., Wright, N., Dawes, L., Kerr, J., & Robertson, A. (2019). Co-design for curriculum planning: A model for professional development for high school teachers. Australian Journal of Teacher Education, 44(7), 84–107. https://doi.org/10.14221/ajte.2019v44n7.6
25. Kline, T. J. . (2005). Psycological Testing : A Practical Approach to Design andEvaluation. Sage Publication.

26. Kong, S. F., & Mohd Effendi, M. M. (2020). Pendekatan STEM dalam proses pengajaran dan pembelajaran : Sorotan Literatur Bersistematik (SLR). JURNAL PENDIDIKAN SAINS & MATEMATIK MALAYSIA, 10(2).
27. KPM. (2013). Pelan Pembangunan Pendidikan Malaysia 2013 - 2025. In Kementerian Pendidikan Malaysia (Vol. 27, Issue 1). https://doi.org/10.1016/j.tate.2010.08.007
28. Krejcie, R. V, & Morgan, D. (1970). Determining Sample Size For Research Activities. In Educational And Psychological Measurement.
29. Miller, L. A., & Lovler, R. L. (2018). Foundations of Psychological Testing : A Practical Approach (sixth edit). Sage Publication.
30. Nanna, M. J., & Sawilowsky, S. S. (1998). Analysis of Likert scale data in disability and medical rehabilitation research. Psychological Methods, 3(1), 55–67. https://doi.org/10.1037//1082-989x.3.1.55
31. Nurul Shahhida, A. B., Siti Mistima, M., & Roslinda, R. (2020). Mathematics teacher's self-efficacy of technology integration and technological pedagogical content knowledge. Journal on Mathematics Education, 11(2), 256–276. https://doi.org/10.22342/jme.11.2.10818.259-276
32. Odell, M. R. L., Kennedy, T. J., Stocks, E., Odell, M. R. L., Kennedy, T. J., & Stocks, E. (2019). The Impact of PBL as a STEM School Reform Model The Interdisciplinary Journal of Problem-based Learning SPECIAL ISSUE : UNPACKING THE ROLE OF ASSESSMENT IN PROBLEM- AND PROJECT-BASED LEARNING The Impact of PBL as a STEM School Reform Model. Interdisciplinary Journal of Problem-Based Learning, 13(2). https://doi.org/10.7771/1541-5015.1846
33. Ong, E. T., Norazura, S., Zaharah, M. J., Sabri, M. S., & Abdul Manas Hanafi, M. N. (2017). STEM EDUCATION THROUGH PROJECT-BASED INQUIRY LEARNING : AN EXPLORATORY STUDY ON ITS IMPACT AMONG YEAR 1 PRIMARY In the quest of becoming a developed nation by 2020 , Malaysia has given great emphases on education . Moreover , given that science , technolo. Jurnal Pendidikan Sains & Matematik Malaysia, 7(2), 43–51.
34. Polit, D. F., Beck, T., & Owen, S. V. (2007). Focus on Research Methods Is the CVI an Acceptable Indicator of Content Validity ? Appraisal and Recommendations. 459–467. https://doi.org/10.1002/nur
35. Rahmat, A., Syakhrani, A. W., & Satria, E. (2021). Promising online learning and teaching in digital age: systematic review analysis. International Research Journal of Engineering, IT & Scientific Research, 7(4), 126–135. https://doi.org/10.21744/irjeis.v7n4.1578
36. Rajendram, S. (2022). "Our country has gained independence, but we haven't": Collaborative translanguaging to decolonize English language teaching. Annual Review of Applied Linguistics, 42, 78–86. https://doi.org/10.1017/S0267190521000155
37. Rehman, N., Huang, X., Mahmood, A., Zafeer, H. M. I., & Mohammad, N. K. (2025). Emerging trends and effective strategies in STEM teacher professional development: A systematic review. Humanities and Social Sciences Communications, 12(1), 1–23. https://doi.org/10.1057/s41599-024-04272-y
38. Sionti, M., Schack, E., & Schack, T. (2018). Hint- Giving Phraseology for Computer Assisted Learning. In Proceedings of The 21st International Conference on Interactive Collaborative Learning (Vol. 1, pp. 133–144). Springer, Cham.
39. Uchima-Marin, C., Murillo, J., Salvador-Acosta, L., & Acosta-Vargas, P. (2024). Integration of Technological Tools in Teaching Statistics: Innovations in Educational Technology for Sustainable Education. Sustainability (Switzerland), 16(19). https://doi.org/10.3390/su16198344
40. Vygotsky, L. (1978). Readings on the development of children. In Interaction between learning and development (pp. 34–41).
41. World Economic Forum. (2018). The Future of Jobs Report. In Executive Summary (Vol. 5, Issue January). https://doi.org/10.1177/1946756712473437
42. Wu, X., Yang, Y., Zhou, X., Xia, Y., & Liao, H. (2024). A meta-analysis of interdisciplinary teaching abilities among elementary and secondary school STEM teachers. International Journal of STEM Education, 11(1). https://doi.org/10.1186/s40594-024-00500-8
43. Zhao, Y., Li, J., & Liu, K. (2023). The sustainable development of mathematics subject: An empirical analysis based on the academic attention and literature research. Heliyon, 9(8), e18750. https://doi.org/10.1016/j.heliyon.2023.e18750