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PAPER

A STEM Teachers' Perspective: Mobile Application Consumption and Their Impact on Students' Creative Academic Performance

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ABSTRACT

This study examines the effect of professional development (PD) programs on STEM teachers' capacity to integrate STEM content into K-12 classrooms in China, employing a rigorous mixed-methods design. The study combines a systematic literature review (SLR) of empirical studies (2016–2023) from major databases (Web of Science, Scopus, ERIC, and CNKI) with quantitative data collected through stratified random sampling of 550 participants (150 teachers, 200 students, and 200 parents) across rural Chinese high schools. The methodology features: (1) a PRISMA-guided systematic review with strict inclusion criteria focusing on STEM PD outcomes and (2) cross-sectional surveys analyzed via SPSS regression to examine relationships between PD participation and teaching efficacy/student outcomes. Thematic findings revealed that mobile apps enhance interactive learning but face adoption challenges due to infrastructural gaps and inadequate teacher training. Quantitative results aligned with the technology acceptance model (TAM), indicating that perceived usefulness (PU) and perceived ease of use are primary drivers of adoption, while perceived risk (PR) negatively impacts behavioral intention. The study concludes that mobile learning holds significant potential for STEM education, but it requires targeted professional development, equitable resource allocation, and risk-mitigation strategies to achieve a scalable impact. Practical implications include policy recommendations for integrating mobile technologies into teacher training programs and addressing socioeconomic disparities in digital access.

KEYWORDS

mobile learning, STEM education, technology acceptance, teacher professional development, digital divide

1 INTRODUCTION

In China's rapidly evolving educational landscape, the Bring Your Device (BYOD) movement has gained significant traction, particularly in STEM education

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(Shurygin et al., 2024). A notable development within this trend is mobile-based assessment (MBA), which utilizes wireless technologies and mobile devices for evaluation purposes. Recent studies highlight the potential of mobile devices (MBAs) to transform learning assessment in Chinese classrooms, where mobile penetration rates exceed 98% nationwide [1]. However, successful implementation depends critically on user acceptance, which remains understudied in China's unique educational context, characterized by centralized curriculum policies, regional resource disparities, and a high-stakes testing culture. While existing research has examined MBA adoption from students' perspectives [2–3].

However, studies show that only a small number of students in STEM fields (science, technology, engineering, and mathematics), which are the focus of this study, actually use technology regularly for their learning [4–5]. A study by Wannapiroon and Pimdee [6] stated that teachers' readiness and expertise in using technology in the classroom, as they direct the way students learn, have the power to either increase or decrease the possibility of using technology in the classroom. The goal of STEM is to break down the barriers between math, science, technology, and engineering, allowing students to apply their knowledge to solve real-world problems and increasing their interest in pursuing careers in these fields. The method of teaching STEM material across two or more disciplines in an authentic setting to tie these subjects together to enhance students' learning is known as "integrating STEM in lessons." The teaching and learning of discipline knowledge, which includes science and/or mathematics, through the integration of engineering methods and the engineering design of pertinent technologies is known as STEM integration [7]. The unique capabilities of mobile applications, including interactive simulations, real-time feedback, and adaptive learning environments, have the potential to support diverse learning styles and promote deeper engagement with STEM content [8]. For instance, educational apps in mathematics and science can provide dynamic visualizations of abstract concepts, helping students better understand complex ideas and processes. Apps designed for engineering and technology often support exploration, thinking, and collaboration with others, which are essential for fostering creativity and innovation in STEM fields [9]. This study explicitly investigates the factors influencing Chinese STEM teachers' intentions to adopt an MBA across diverse regional settings, ranging from technologically advanced urban centers to resource-constrained rural schools. Building on the technology acceptance model (TAM), we incorporate contextual factors particularly relevant to China's educational system, including institutional support mechanisms, regional infrastructure disparities, curriculum alignment pressures, and societal attitudes toward technology-mediated assessment.

2 LITERATURE REVIEW

Mobile learning, defined as the use of portable devices to facilitate learning anytime and anywhere, is gaining traction as a practical approach in STEM education [10]. Numerous studies highlight the versatility of mobile apps in delivering interactive content, providing immediate feedback, and enabling learners to visualize abstract STEM concepts [11]. For example, math apps often feature dynamic simulations and gamified problem-solving exercises, while science apps can offer virtual laboratories and augmented reality (AR) experiences. These affordances not only make learning more engaging but also help bridge the gap between theoretical knowledge and real-world applications [12]. Employing technology in the classroom promotes student enthusiasm and achievement, as well as the development of new skills and the application of modern teaching methodologies [13]. Research has identified several obstacles to the use of technology in the classroom, ranging from first-order issues, such as a lack of software or technological access, to second-order issues, including teachers' attitudes toward technology and instruction [14]. First-order hurdles have diminished in importance as technology has advanced, providing more access and technical assistance for the use of mobile devices in the classroom [15]. Various studies are being conducted to investigate how mobile apps can enhance creativity and academic performance in STEM subjects. Experts now consider creativity, which leads to new and beneficial ideas, more essential for success in STEM fields. When students use apps that offer open-ended tasks and allow them to collaborate and share actual information, they tend to try new things, take intellectual risks, and solve problems [16]. Experts propose that mobile apps are most effective when they align with teaching objectives and encourage students to stay engaged during learning.

A study revealed that students using science simulation apps achieved a better understanding and applied creative methods to investigate. Additionally, it was found that students who used math apps felt more confident and were willing to work on more challenging mathematics problems. However, how much creativity and academic performance improve may depend on design, classroom environment, and the supervision offered by the teacher [17]. There are now two distinct perspectives on the use of cell phones in the classroom. On the one hand, some people extol the benefits of mobile devices in the classroom. They contend that features such as internet access, the ability to run educational apps, and their use as readers or "clickers" validate their inclusion in the classroom [18]. However, there is a discourse that exaggerates the detrimental consequences of these gadgets on education, including their capacity to divert attention, their use to cheat on tests, cyberbullying, and their availability of offensive material. These are the same arguments, positives, and negatives that have been raised since the computing model was introduced. Furthermore, the mobile phone is perceived as a potential distraction and a technology that presents more risks than advantages, as evidenced by the messaging in the news and the prevailing societal conversation [18].

There are still some hurdles that make it hard for mobile applications to be used effectively in STEM learning. In many under-resourced areas, some students still lack access to robust devices or top educational apps [19]. Some educators and parents may limit mobile device use in schools because they worry about excessive screen time, the potential for distraction by technology, and privacy concerns. Mobile apps need to align with existing curriculum guidelines, as those that do not may provide students with a fragmented learning experience or diminished academic value. It is also challenging to find teachers who are ready for the job. Several educators state that they lack the confidence to choose, judge, and bring mobile apps into the classroom. These professional development (PD) programs are not always well-structured, so educators often lack the proper guidance on how to use technology effectively. Therefore, mobile apps may be underutilized, failing to take full advantage of their unique qualities [20].

Many studies have examined student achievements and the effectiveness of education apps, yet very few have investigated how STEM teachers feel about using them [21]. Listening to teachers helps you grasp the realities of using technology in classrooms, including what works well for them and what limits their effectiveness. Furthermore, few studies have examined how mobile apps influence STEM students' creativity, as perceived by teachers. Closing these gaps is necessary for advising on education policy, building effective professional development, and constructing mobile applications that benefit educators and their students.

3 METHODS AND MATERIALS

3.1 Study design

This study used a mixed-methods approach, combining a systematic literature review (SLR) with a quantitative survey. The goal was to assess the impact of PD programs on K–12 STEM teachers' ability to integrate STEM content in Chinese classrooms.

3.2 Search strategy

A systematic search was conducted in Web of Science, Scopus, ERIC, CNKI, and Google Scholar for English and Chinese studies published between January 2016 and November 2023. Keywords included "STEM," "teacher professional development," "China," and "K–12." Reference lists were also screened, and duplicates were removed using reference management software. From 2,500 initial records, 1,000 duplicates were removed. After title, abstract, and full-text screening, 200 studies met the inclusion criteria. The selection process followed PRISMA guidelines and is illustrated in Figure 1.

3.3 Inclusion and exclusion criteria

Studies included had to present empirical findings on STEM PD for K–12 in-service teachers in China, with a focus on integrating STEM content and pedagogy using frameworks like social cognitive theory (SCT) or technological pedagogical content knowledge (TPCK). Both qualitative and quantitative studies in English or Chinese were accepted if they assessed outcomes such as teacher efficacy, instructional methods, or student engagement. Excluded were studies on higher education faculty, theoretical papers, literature reviews, and any research lacking empirical data or a specific STEM integration focus.

3.4 Data extraction

Key details from eligible studies were extracted using a standardized template, covering authorship, publication language, study design, participant characteristics, PD program details, theoretical framework, and outcome measures related to STEM teaching and engagement.

3.5 Implementation and experimental procedures

A cross-sectional survey, complemented by interviews, was used to collect both quantitative and qualitative data from STEM students, teachers, and parents in rural Chinese high schools. Stratified random sampling was used to ensure representation across socioeconomic and geographic groups. From 12 schools, 200 grade 12 STEM students, 200 parents, and 150 teachers were randomly selected, yielding a total sample of 550 participants. Structured questionnaires captured demographics, attitudes, and experiences related to STEM professional development. Descriptive statistics summarized the data, and regression analysis in SPSS tested the relationships between PD and outcomes, such as teacher efficacy and student engagement. Institutional ethics approval was obtained. Participation was voluntary, with informed consent collected from all adults and guardians of minors. Anonymity and confidentiality were maintained, and data were used solely for research purposes in compliance with ethical guidelines.

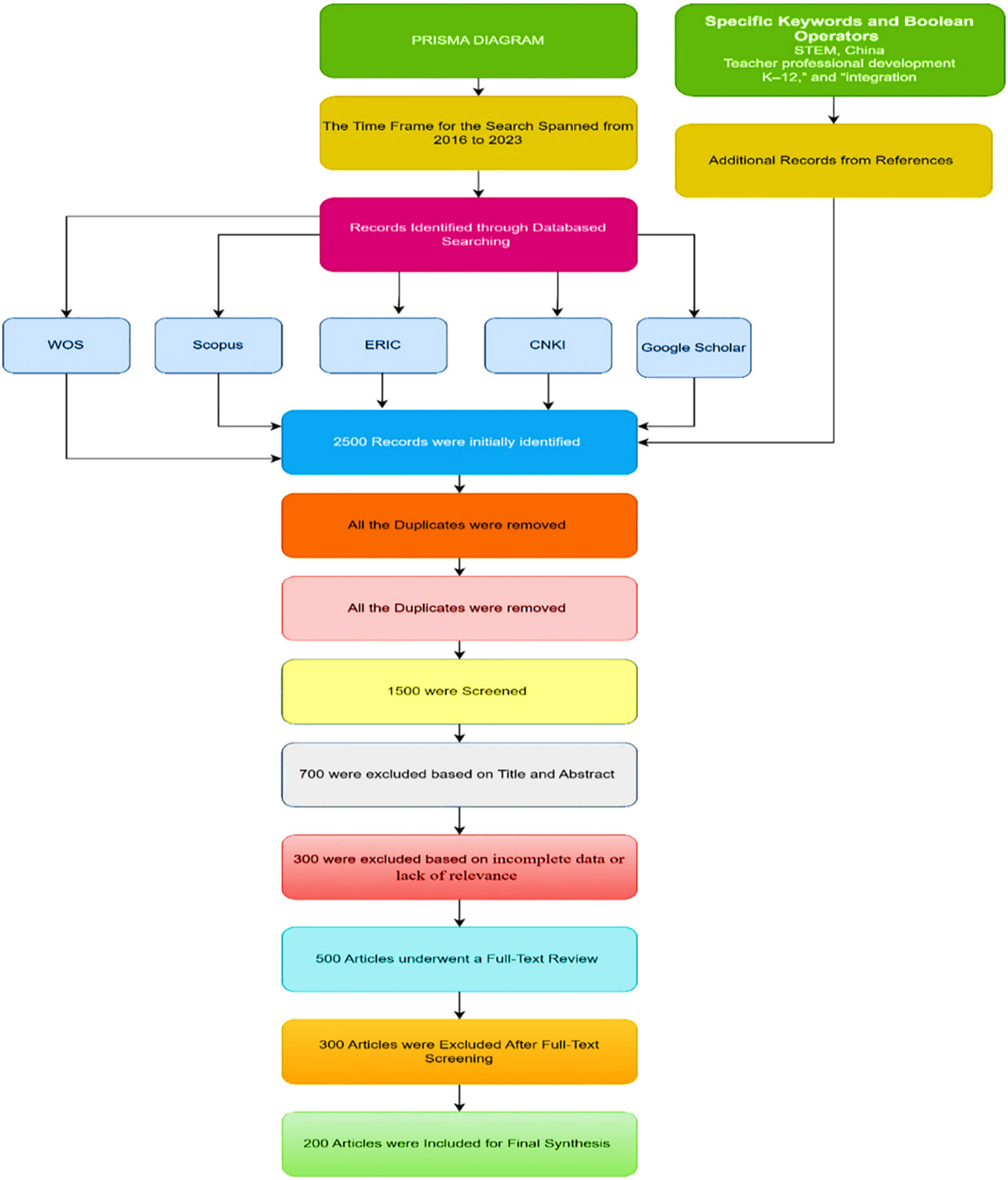

Fig. 1. PRISMA diagram

4 RESULTS AND DISCUSSION

4.1 Findings of systematic review

The SLR revealed several key themes regarding the impact of PD programs on STEM teachers' capacity to integrate STEM content into K–12 classrooms in China. Predominant themes included (1) the enhancement of teacher efficacy and STEM literacy through targeted PD interventions, (2) the influence of theoretical frameworks such as TPCK and SCT in shaping PD design and outcomes, (3) the role of PD in fostering innovative instructional practices and classroom engagement, and (4) the contextual challenges and socioeconomic factors affecting PD implementation in rural versus urban settings. These themes emerged consistently across empirical studies, highlighting the interplay between the structure of PD programs, teacher preparedness, and student outcomes. The synthesis of these findings provides a foundation for discussing their implications for policy and practice in STEM education.

The enhancement of teacher efficacy and STEM literacy. Evidence from the systematic review suggests that PD programs with a clear structure significantly enhance a teacher's confidence in teaching STEM and their subject knowledge. This aligns with previous research that has demonstrated how PD helps empower teachers [22]. Several studies have shown that long-term PD focused on content leads to increased confidence and ability to teach various STEM lessons among teachers. For example, educational programs that utilize inquiry and practical application strategies have been shown to lead to better pedagogical content knowledge (PCK), thereby improving the effectiveness of teaching [23]. The review found significant inconsistencies. Although studies have shown that PD can help teachers feel more effective, some emphasize that improvements depend on the support and relevance teachers are given. As a result, the success of PD programs depends on their setup and assistance from schools rather than solely on the number of participants. Furthermore, the use of self-reported data in studies may result in social desirability bias, suggesting more efficacy than what is proved in classrooms. It was clear that there were not enough studies following teachers over time to check if their performance and student achievements improved after training. Studies on short-term results are readily available, but few reports capture the results for teachers beyond six months, making it difficult to measure the long-term benefits [24].

It was shown that PD programs in China for STEM rely heavily on the theories of TPCK and SCT. Some PD activities were designed using these frameworks, with TPCK guiding the integration of technology into teaching subjects and SCT teaching teachers how to enhance their self-esteem in teaching through imitation and practice of best practices. Although a strong basis supports their role in economics, the review highlighted both areas where they excel and those where they fall short. Programs centered around TPCK have significantly improved teachers' ability to integrate subject matter, teaching methods, and technology, which is important in STEM education [19]. The report did mention that significant hurdles exist in carrying out the recommendations. Many of these learning programs employed a fixed framework for TPCK rather than making it flexible to match each context, which resulted in overlooking the unique aspects of each subject [20]. For instance, PD for physics teachers usually focuses more on non-specific technical tools (such as simulations) rather than on how to explain abstract concepts visually. Moreover, researchers relied on surveys that people filled out rather than observing classes, which may have affected the accuracy of the findings.

4.2 Quantitative findings

Table 1 shows the descriptive statistics provide a fundamental overview of the dataset, offering crucial insights into the central tendencies, variability, and distributional characteristics of the measured constructs. These statistics serve as the foundation for more advanced analyses by verifying data quality, identifying potential outliers, and ensuring that the assumptions of subsequent inferential tests are met. In this study, descriptive statistics were particularly valuable in establishing the baseline characteristics of the mobile learning acceptance model's constructs.

Table 1. Descriptive statistics

Construct	Mean	SD	Skewness	Kurtosis	Min	Max
ATT	4.12	0.78	–0.45	1.22	2	5
BI	3.98	0.85	–0.32	0.98	1	5
PEN	3.45	0.91	0.12	–0.45	1	5
PEOU	4.23	0.67	–0.67	1.45	2	5
PPR	3.67	0.73	–0.23	0.67	1	5
PR	3.12	0.88	0.34	–0.12	1	5
PSI	3.89	0.76	–0.56	1.34	2	5
PSR	3.54	0.82	–0.12	0.45	1	5
PU	4.05	0.71	–0.78	1.67	2	5

Table 1 gives a summary of all the constructs in the mobile learning acceptance model, helping us learn about how respondents see things and the shape of the data. According to the findings, teachers rated perceived ease of use (4.23) and perceived usefulness (PU) (4.05) the highest, which reflects a firm belief in the easy and helpful aspects of mobile learning, while perceived risk (PR) (3.12) had the lowest rating, showing that these concerns were still present. Average standard deviations (0.8–0.9) reveal that responses are often dispersed around the average value, without extreme changes. The values of skewness (–0.78 to 0.34) and kurtosis (–0.45 to 1.67) are within the recommended ranges (±2) for normal data, confirming that parametric analysis can be applied.

Table 2. Correlation matrix of constructs

Variables	ATT	BI	PEN	PEOU	PPR	PR	PSI	PSR	PU
ATT	1								
BI	0.78*	1							
PEN	0.07	0.1	1						
PEOU	0.43*	0.38*	0.12	1					
PPR	0.05	0.05	0.46*	0.09	1				
PR	0.35*	0.24*	0.09	0.45*	0.09	1			
PSI	0.08	0.17*	0.03	0.09	0.08	0.15	1		
PSR	0.06	0.08	0.45*	0.03	0.74*	0.06	0.05	1	
PU	0.48*	0.45*	0.09	0.36*	0.08	0.23*	0.05	0.04	1

Table 2, the correlation matrix, reveals significant relationships between key constructs of the mobile learning acceptance model while demonstrating appropriate discriminant validity. Strong positive correlations between attitude (ATT) and behavioral intention (BI) (r = 0.78) and between perceived self-regulation and perceived playfulness (r = 0.74) highlight crucial predictive relationships in the acceptance model, while moderate correlations between PU and both ATT (r = 0.48) and BI (r = 0.45) underscore its central role in adoption decisions.

Regression analysis. Regression analysis was conducted to examine the predictive relationships between key constructs in the mobile learning acceptance model. Given the exploratory nature of this study, multiple linear regression (MLR) was employed using SPSS to assess how different factors (independent variables) influence BI and ATT as dependent variables. MLR is appropriate for this analysis, as it allows for the simultaneous evaluation of multiple predictors while controlling for their intercorrelations, providing insights into which factors most significantly contribute to acceptance outcomes. The analysis included checks for multicollinearity (VIF < 4), normality of residuals, and homoscedasticity to ensure robust results.

Table 3. Model summary and fit statistics

Model	R	R^2	Adjusted R^2	Std. Error	Durbin-Watson	F-Statistic	p-Value
BI	0.82	0.672	0.658	0.421	1.892	48.73	<0.001
ATT	0.737	0.543	0.525	0.487	1.956	29.84	<0.001

Table 3 shows the model summary, and fit statistics demonstrate strong predictive power and reliability for both regression models examining mobile learning acceptance. For the BI model, the high R^2 value of 0.672 indicates that 67.2% of variance in BI is explained by the predictor variables, with an adjusted R^2 of 0.658 confirming minimal overfitting. Similarly, the ATT model accounts for 54.3% of variance (adjusted R^2 = 0.525). Both models show excellent statistical significance ($p < 0.001$) with robust F-statistics (48.73 for BI; 29.84 for ATT), confirming the overall model fit. The Durbin-Watson statistics (1.892 for BI; 1.956 for ATT) fall within the ideal 1.5–2.5 range, indicating independent residuals with no autocorrelation, while the relatively low standard errors (0.421 for BI; 0.487 for ATT) suggest precise coefficient estimates.

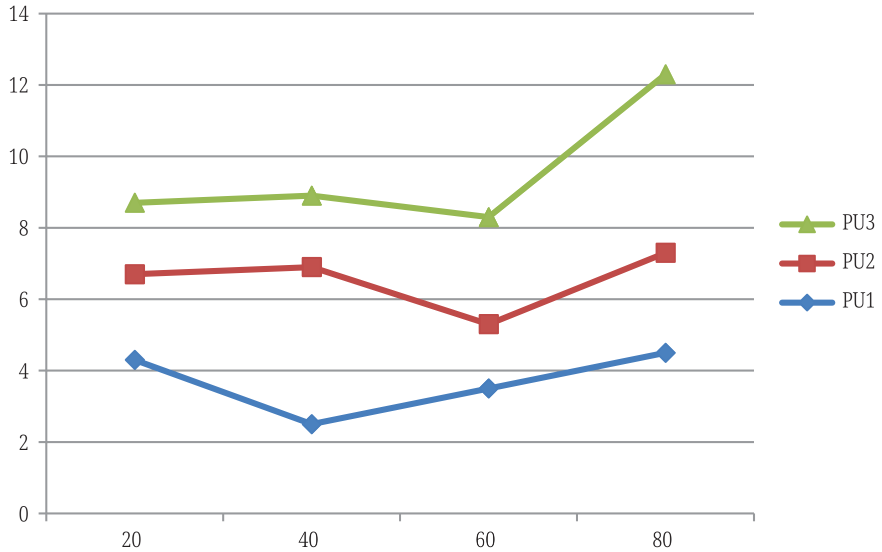

Fig. 2. The internal model of the high school's taking of the mobile learning model

Table 4. Regression analysis predicting BI

Predictor	Unstd. β	Std. β	t-Value	p-Value	95% CI (Lower, Upper)	VIF	R^2	Adj. R^2	F-Statistic (p-Value)
(Constant)	0.45	–	1.24	0.217	(–0.25, 1.15)	–	0.672	0.658	48.73 (0.000)
ATT	0.52	0.41	6.87	0	(0.36, 0.68)	1.36			
PEOU	0.31	0.28	4.12	0	(0.16, 0.46)	1.53			
PU	0.29	0.25	3.89	0	(0.14, 0.44)	1.41			
PR	–0.18	–0.12	–2.45	0.015	(–0.32, –0.04)	1.11			
PSI	0.09	0.07	1.56	0.12	(–0.02, 0.20)	1.46			

Table 4 shows regression analysis reveals significant predictors of BI toward mobile learning adoption. ATT emerges as the strongest positive predictor (β = 0.41, p < 0.001), followed by perceived ease of use (PEOU, β = 0.28, p < 0.001) and (PU, β = 0.25, p < 0.001), confirming core TAM constructs. PR shows a significant negative influence (β = –0.12, p = 0.015), while personal innovativeness (PSI) proves non-significant (p = 0.12). The model explains 67.2% of BI variance (Adj. R^2 = 0.658), with all variance inflation factors (VIFs) below 2, indicating no multicollinearity concerns. The highly significant F-statistic (48.73, p < 0.001) confirms the model's overall robustness, suggesting that enhancing positive attitudes and usability perceptions while mitigating risk concerns could effectively promote mobile learning adoption.

Table 5. Regression analysis predicting ATT

Predictor	Unstd. β	Std. β	t-Value	p-Value	95% CI (Lower, Upper)	VIF	R^2	Adj. R^2	F-Statistic (p-Value)
(Constant)	0.62	–	2.01	0.045	(0.01, 1.23)	–	0.543	0.525	29.84 (0.000)
PEOU	0.38	0.34	5.12	0	(0.23, 0.53)	1.18			
PU	0.33	0.3	4.67	0	(0.19, 0.47)	1.14			
PR	–0.15	–0.1	–2.01	0.045	(–0.30, –0.00)	1.09			
PSI	0.07	0.06	1.22	0.224	(–0.04, 0.18)	1.45			

Table 5 shows regression analysis for ATT toward mobile learning reveals three significant predictors, collectively explaining 54.3% of variance (Adj. R^2 = 0.525). PEOU demonstrates the strongest positive influence (β = 0.34, p < 0.001), closely followed by (PU, β = 0.30, p < 0.001), confirming their fundamental role in shaping positive attitudes. PR shows a modest but significant negative impact (β = –0.10, p = 0.045), while Personal Innovativeness (PSI) fails to reach significance (p = 0.224). The model's robustness is confirmed by a highly significant F-statistic (29.84, p < 0.001) and absence of multicollinearity (all VIFs < 1.5). Notably, the intercept's significance (p = 0.045) suggests additional unmeasured factors contribute to baseline attitudes.

Table 6. ANOVA results for regression models

Model	Sum of Squares	df	Mean Square	F	p-Value
BI Regression	34.52	5	6.904	48.73	<0.001
Residual	16.83	119	0.141		
Total	51.35	124			

(Continued)

Table 6. ANOVA results for regression models *(Continued)*

Model	Sum of Squares	df	Mean Square	F	p-Value
ATT Regression	28.15	4	7.038	29.84	<0.001
Residual	23.72	120	0.198		
Total	51.87	124			

Table 6 ANOVA results demonstrate highly significant predictive relationships for both regression models ($p < 0.001$), confirming their statistical validity. For the BI model, the substantial F-value of 48.73 (df = 5,119) indicates that the collective predictive power of the independent variables is significantly greater than the unexplained variance, with the regression component accounting for 34.52 of the total 51.35 sum of squares. Similarly, the ATT model shows strong predictive capability ($F = 29.84$, df = 4,120), explaining 28.15 of the total 51.87 sum of squares. The relatively small residual mean squares (0.141 for BI; 0.198 for ATT) suggest good model fit, with minimal unexplained variance remaining after accounting for the predictor variables.

5 DISCUSSION

Analysis of the themes showed how STEM teachers view mobile application usage in schools and what effects it may have on students' academic creativity. Mobile learning tools seem to have supported a big shift in teaching, making students more involved thanks to interactive and personal activities. Many professionals thought that technology promoting simulated activities, programming, and AR made it simpler for students to apply STEM ideas to real situations. Many people wrote about challenges with implementation, which were especially problematic in rural schools that are lacking resources. Differences in devices and help with technology and digital knowledge were pointed out by teachers as barriers to fair adoption across the organization. This finding is in line with past studies (Shurygin et al., 2024), confirming that students' access to devices and technology is mediated by social class.

Another big area explored the importance of teacher development in utilizing mobile learning fully. Many pointed out that PD focused on the use of apps helped them come up with innovative approaches in their classrooms. As an example, by participating in communities of practice, teachers had chances to work together to enhance their lessons with mobile devices, focusing on their specific subject needs. There were issues with sustainability; participants may have felt more confident short-term, though keeping up with mobile devices for long was often hindered by their school's curriculum and lack of support from teachers. This points out with Tantu (2017) that PD has to be regular and adjusted for the context to make real changes. Overall, these themes suggest that before mobile applications greatly help education, we must address main issues and put teachers in charge of deciding how to implement them.

Mobile learning acceptance was supported by regression analyses, making it clear that PU and PEOU play the biggest roles in influencing student attitudes and intentions toward using mobile devices for learning. This supports Davis's (1989) TAM because it identifies utility and usability as the main determinants of a user's decision to adopt a product. Remarkably, the explanatory strength of the BI model ($R^2 = 0.672$) indicates that the cognitive effects and attitude do well in explaining mobile learning acceptance. PR had a strong influence on BI ($\beta = -0.12$, $p = 0.015$) and pointed out security and privacy concerns as main barriers, like previous findings in educational technology [21]. The outcomes were strengthened by the models showing good fit and fulfilling the key statistical demands. When combined with qualitative observations, these results make it clear there are two important goals: (1) improve the usefulness of mobile apps by focusing on users and (2) address the fears teachers may have about data by ensuring all policies are clear and teachers have proper training. Moving forward, interventions should use these evidence-based routes to support more STEM education in schools.

5.1 Policy implications for practice

For mobile learning in STEM to be effective, authorities and educational systems should focus on giving equal resources so that all schools, particularly in rural and marginalized regions, get the tools and support they require. Programs for teacher professional learning (PD) must focus more on hands-on experience using mobile devices along with STEM practices, giving guidance and support to educators and encouraging them to share and make lessons together. Besides, curriculum frameworks ought to include mobile learning strategies explicitly, keeping them upcoming with competency-based learning priorities and making sure data privacy is dealt with by including clear rules and training for digital literacy. Public-private partnerships can boost innovation by bringing ed-tech experts to help build applications that fit the classroom and are user-friendly. Such planned steps will ensure mobile learning transforms from being an idea into making STEM education better.

6 CONCLUSION

The analysis combines exploratory interviews with teachers and thorough data analysis to fully explore the adoption of mobile learning in STEM education. These findings suggest mobile applications are likely to help creative learning, but this can be hugely impacted by access to technology, how well teachers are trained, and the level of institutional help offered. Analysis of the themes highlighted that teaching practices improve when mobile technology is tied to learning objectives and teachers keep updating their skills, but difficulties remain, especially in underserved parts of society, which call for well-targeted policies. The study's figures verified the TAM in this case, showing that what decides whether someone will adopt the technology are PU and ease of use, yet PR is an obstacle. All of these studies suggest that effective mobile learning in STEM education calls for both new technology and plans that handle challenges with infrastructure, teacher training, and user questions.

To keep improving, this study advises: (1) infrastructure investment to give every student and teacher the tools they require to use technology in their lessons; (2) realignment of the way teachers are trained, making it more focused and ongoing; and (3) improving the design of mobile learning applications so that users feel they are beneficial and risks are reduced through clear data use policies. More research is needed to see how mobile learning affects students' creativity in the long run, and studies should also look at how social and cultural environments shape students' use of mobile devices in education.

6.1 Limitations and future research

However, there are limitations to take into account while examining the research on mobile learning in STEM education. Collecting information from teachers and students could cause response bias, and it is difficult to say from this study how mobile learning will affect academic performance over the long term. Another point is that the majority of the sample was made up of schools in China, which could make it difficult to generalize study findings to different cultural or educational settings. Third, the researchers did not review individual mobile application features, so it is unclear how these might have impacted how usable the program was and how learning results were obtained. Diverse future studies should include longitudinal mixed methods and include standardized test scores and creative assessments to show how mobile learning has an impact and compare mobile learning results among people and places with different social and economic backgrounds. In addition, research can examine how using games or simulations in apps impacts people's interest and understanding of science, technology, engineering, and math.

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