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RESEARCH ARTICLE

Examining the effect of Digital Literacy on Technology Integration: Evidence from Chinese Private Universities

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ABSTRACT

Digital technologies are increasingly reshaping teaching practices in higher education institutions. Nevertheless, many private universities in China, particularly those located in Shandong Province, still faces difficulties when incorporating digital technologies into teaching. These challenges often related to limited institutional resources and insufficient digital competencies among teachers. In such a context, understanding how teachers' digital capabilities support technology integration becomes increasingly important. This research focuses on the role of teachers' digital literacy in facilitating technology integration in private universities in Shandong Province, China. A quantitative cross-sectional survey design was employed. Data were collected from 423 teachers using structured questionnaires adapted from the Digital Literacy Skills Scale (DLSS) and the Teacher Technology Integration Survey (TTIS). The dataset was analysed using Partial Least Squares Structural Equation Modeling (PLS-SEM) with the SmartPLS software. The results suggest that teachers reported moderate levels of digital literacy as well as moderate levels of technology integration in their instructional practices. Structural model analysis further indicates a statistically significant positive relationship between digital literacy and technology integration ($\beta = 0.653$, $t = 23.938$, $p < 0.001$). Digital literacy accounted for 42.6% of the variance in teachers' technology integration behaviour. The results point to the need to further strengthen teachers' digital competencies through targeted professional development and institutional support in order to promote more effective technology integration in private higher education institutions.

Contribution/Originality: This study contributes to the existing literature by providing empirical evidence on the impact of teachers' digital literacy on technology integration in Chinese private universities, an underexplored context. Using PLS-SEM analysis of 423 teachers, the findings confirm digital literacy as a significant predictor, explaining meaningful variance and informing teaching practice.

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1. Introduction

In the context of rapid digital transformation, integrating technology into teaching has become an important issue in higher education, cultivates innovative pedagogical approaches, propels elevated learning outcomes (Akram et al., 2022; Howard et al., 2021). In China, national strategies including Education Informatization 2.0, advance the application of digital tools in higher education. Private universities in Shandong Province, encounter obstacles in infrastructure construction, and faculty preparation, fall behind public higher education institutions (Liang, 2021). This underscores the urgency to examine factors driving effective technology integration.

Technology integration refers to the deliberate application of digital technologies, to optimize instructional practices, and improve student learning outcomes (Akram et al., 2022). Teachers' digital literacy is widely acknowledged as a core prerequisite, for the effective implementation of educational technologies, covers technical, cognitive, and socio-emotional competencies, in the access, evaluation, and utilization of digital resources (Ng, 2012; Valverde-Berrocoso et al., 2021). These conceptualizations constitute the fundamental basis, for educators to develop technology-enriched learning contexts.

Research confirms that teachers' digital literacy play an important role in shaping their ability to incorporate technology into teaching practices and to create innovative learning environments (Purnomo et al., 2023; Valverde-Berrocoso et al., 2021). Public universities exhibit superior performance, benefit from more adequate resource (Yang, 2023). Empirical investigations focusing on such associations, among private universities in Chinese mainland, particularly those within Shandong Province, are still inadequate, fail to capture context-specific constraints and localized obstacles.

This study explore the effects of teacher's digital literacy on technology integration, in private higher education institutions, in Shandong Province, China. By adopting a quantitative research design and applies partial least squares structural equation modeling (PLS-SEM), this research collect data from in-service teachers in private universities and analyzes the direct relationship between digital literacy (DLit) and technology integration (TI), together with its explanatory power. The findings are intended to enrich the scholarly literature on technology integration in private higher education and provide empirical implications for policymakers, institutional administrators and practitioners committed to enhancing digital teaching capacity.

This study supports the key role of teachers digital literacy on technology integration, and contribute to the literature on digitalization of education in Chinese private higher education, notably in the scarcely researched context of Shandong Province. The findings provide practical suggestions for policy makers and university managers to strengthen instructors' digital abilities and improve facility systems, supporting more balanced digital development across higher education institutions.

1.1. Research Objectives

Previous studies have highlighted the importance of teacher's digital competencies in supporting the effective use of educational technologies. Nevertheless, empirical evidence from private higher education institutions in Shandong Province, China, remains relatively limited. In particular, it is still unclear how teachers' digital literacy is

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reflected in their teaching practices and how it relates to the integration of digital technologies in classroom instruction.

Against this background, the present research seeks to examine the role of teachers' digital literacy in technology integration within private universities in Shandong Province, China. To address this issue, the study is guided by the following research objectives:

RO1: To describe the current levels of teachers' digital literacy and the extent to which digital technologies are used in teaching within private universities in Shandong Province, China.

RO2: To examine the relationship between teachers' digital literacy and their level of technology integration in teaching practices.

RO3: To analyse the influence of teachers' digital literacy on technology integration in instructional activities.

1.2. Research Questions

To further clarify the issues addressed in this research, several questions are formulated based on the research objectives outlined above. These questions guide the empirical investigation of teachers' digital literacy and its role in technology integration within private universities in Shandong Province, China.

RQ1: What are the current levels of teachers' digital literacy and technology integration in private universities in Shandong Province, China?

RQ2: Is there a statistically significant relationship between teachers' digital literacy and technology integration in teaching practices?

RQ3: How does teachers' digital literacy contribute to the integration of digital technologies in classroom instruction?

1.3. Research hypothesis

Existing research suggests that teachers' digital literacy plays an important role in shaping how digital technologies are used in teaching practices. Teachers with stronger digital competencies are generally better prepared to incorporate technological tools into their instructional activities. Accordingly, the following hypothesis is examined:

H1: Teachers' digital literacy is positively related to technology integration in private universities in China.

2. Literature Review

Digital technology development has gradually changed teaching practice in higher education in recent years. Within the Chinese higher education system, instructional technology integration has attracted continuous academic attention, with a specific focus on private universities in Shandong Province. Compared with public institutions, many of these universities face greater constraints in terms of resources, which may

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slow the process of digital transformation (Liang, 2021). In this context, teachers' ability to make effective use of digital tools plays an important role in improving both teaching quality and student learning outcomes. Consequently, technology integration has become an important topic in educational research, especially in studies examining the factors that support innovative teaching practices. In these context, teachers' capacity to effectively use digital tools has become essential for improving instructional quality and advancing student learning outcomes, and research on technology integration has emerged as a core field in educational research , notably in examining the determinants of innovative pedagogical approaches.

2.1. Technology Integration

Technology integration in educational research generally refers to the purposeful use of digital tools and technological resources in teaching activities to enrich instructional processes and support improved learning outcomes (Akram et al., 2022; Ertmer et al., 2012; Jadhav et al., 2022). This study defines teachers' technology integration as the deliberate application of digital technologies in teaching procedures to support student learning and achieve pedagogical goals. The construct includes several dimensions: teachers' willingness to try new technologies, confidence in digital tool application, and perceived instructional value brought by technology in classroom settings (Karakis, 2022; Njiku et al., 2019; Vannatta & Banister, 2009).

This study measures technology integration through four dimensions using the Teacher Technology Integration Survey (TTIS) (Vannatta & Banister, 2009):

i. Risk-taking Behaviors and Comfort with Technology (RC): Teachers' willingness to try innovative digital tools, confidence in technology use and independent problem-solving capacity.
ii. Perceived Benefits in using Technology in the Classroom (PB): Teachers' recognition of technology's value to try innovative digital tools, confidence in technology use and independent problem-solving capacity.
iii. Beliefs and Behaviors about Classroom Technology Use (BB): Consistency between teachers' technology-related beliefs and actual classroom practice, including digital integration frequency and effectiveness.
iv. Technology Support and Access (TSA): Availability of institutional resources, technical support, and digital infrastructure that enable technology integration.

2.2. Digital Literacy

Digital literacy is widely recognized as one of the core competencies for the 21st century (Mehmood, 2023; Nelson & Hawk, 2020; Vanek et al., 2020). It refers to the ability to effectively use information and communication technologies to identify, obtain, evaluate, create and transmit information through digital platforms (Gurung & Rutledge, 2014; Limon & Nartgün, 2020). In this study, teachers' digital literacy refers to multi-dimensional abilities that support effective digital technology use in educational settings to achieve teaching and learning goals (Bravo et al., 2021; Ng, 2012). It includes teachers' capacity to solve technical problems, process digital information critically and collaborate through online platforms (Law et al., 2018; Ustundag et al., 2017).

This study measures digital literacy through three dimensions using the Digital Literacy Skills Scale (DLSS) (Ng, 2012):

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i. Technical Skills (TS): Teachers' proficiency in solving technical problems, learning new technologies and applying digital tools for teaching purposes.
ii. 2）Cognitive Skills (CSs): Teachers' ability to critically search, evaluate, and use online information in professional practice.
iii. Social-Emotional Skills (SEs): Teachers' competence in collaborate, communication and support-seeking through digital platforms in educational environments.

2.3. The Role of Teachers' Digital Literacy in Technology Integration

Empirical evidence shows that instructors' digital literacy strongly promotes technology application in classroom teaching. Teachers with advanced digital skills can better select suitable digital resources, design technology-based learning plans and solve practical obstacles in teaching implementation (Khan & Gul, 2022). Previous research also indicates that digital literacy serves as a significant predictor of technology integration, explaining a notable portion of variation in teachers' instructional technology application (Ramli & Mohamad Arsad, 2023).

The Technology, Pedagogy, and Content Knowledge (TPACK) framework explains the internal mechanism of this relationship. It demonstrates how teachers' digital literacy supports the combination of technological knowledge, pedagogical methods and subject-specific content (Shafie & Jamaluddin, 2025). However, much of the existing literature has concentrated on public school systems or educational contexts in Western countries. Within China's private higher education sector, relevant empirical investigations are still insufficient, especially in provinces like Shandong. Resource shortages and infrastructure gaps often restrict the efficient application of digital technologies in instructional practice (Liang, 2021). This research gap requires regional investigation on how teachers' digital competencies drive technology integration under institutional limitations.

3. Research Methods

3.1. Research Design

This research adopts a quantitative cross-sectional survey design to explore the relationship between teachers' digital literacy and technology integration. The study collects data from teachers employed at private universities across Shandong Province, China. A structured questionnaire is used to measure research-related variables. The dataset was subsequently analyzed to determine how teachers' digital competence affects the integration of technological tools within instructional settings.

3.2. Conceptual Framework

Figure 1 illustrates the conceptual framework and the relationships among the variables in this research. Conceptual framework shows the relationship between specific variables in the study. Teachers' digital literacy functions as the independent variable and technology integration as the dependent variable. Digital literacy comprises three dimensions. While technology integration is reflected through four dimensions. This research aims to explore the impact of teachers' digital literacy on teachers' technology integration in private universities in Shandong province of China.

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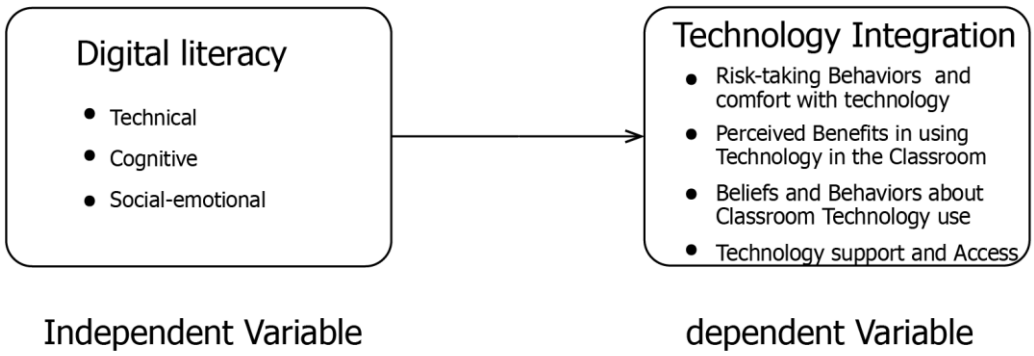
Figure 1: Conceptual framework of Study



3.3. Measurement Instruments

The questionnaire for this study was adopted and adapted from two established instruments: the Digital Literacy Skills Scale (DLSS) developed by Ng (2012) and the Teacher's Technology Integration Survey (TTIS) developed by Vannatta and Banister (2009). The DLSS was used to measure teachers' digital literacy across three dimensions: technical, cognitive, and social-emotional competencies. The TTIS assessed teachers' technology integration in instructional practices. The questionnaire survey consisted of 36 items in total, consist 16 items measuring digital literacy and 20 items measuring technology integration. All questionnaire items were assessed on a five-point Likert-type scale, with response options spanning from strong disagreement to strong agreement. A summary of the study variables and instruments is presented in Table 1.

Table 1: Description of Variables

Variable	Instrument	Number of Items	Scale Used
Digital Literacy	Digital Literacy Skills Scale (DLSS) (Ng, 2012)	16	5-point Likert Scale
Technology Integration	Teacher's Technology Integration Survey (TTIS) (Vannatta & Banister, 2009)	20	5-point Likert Scale

3.4. Sample and Data Collection

Teachers employed in private universities across Shandong Province, China, formed the population for this study. Shandong Province is one of the major regions of higher education in China and has a large number of private universities. Therefore, teachers from private universities in Shandong Province were selected as the sample to examine the relationship between digital literacy and technology integration in this context..

Participants were selected through a multi-stage sampling approach. Qingdao, Jinan and Weifang were initially selected as three representative cities in Shandong Province to reflect diverse regional conditions. Eight private universities in these cities were then chosen as research sites. Teaching staff from selected universities were invited to participate in the survey through random sampling. Statistical data from the Shandong Provincial Department of Education (2023) show about 35,429 teachers employed in

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private higher education institutions across Shandong Province. According to the sample size table developed by Krejcie and Morgan (1970), a minimum sample of 380 respondents was considered adequate. Data were collected via the Wenjuanxing online survey platform, yielding 453 questionnaires. After screening the returned questionnaires, 423 valid questionnaires were included in subsequent statistical analysis.

3.5. Data Analysis

Two statistical software programs, SPSS and SmartPLS, were used to analyse the collected data. SPSS was first employed to generate descriptive statistics, which provided an overview of teachers' levels of digital literacy and their use of technology in teaching practices.

To investigate the relationships among the study variables, Partial Least Squares Structural Equation Modeling (PLS-SEM) was subsequently performed using SmartPLS. The approach is suitable for analysing relationships among latent variables and for evaluating complex research models. In addition, PLS-SEM is widely used in educational and social science research because it allows researchers to test theoretical relationships and evaluate proposed hypotheses simultaneously.

4. Results

4.1. Descriptive Statistics

The survey administered through the Wenjuanxing platform generated 453 responses. After checking the responses for completeness and removing invalid entries, 423 questionnaires were retained for further analysis. This corresponds to an effective response rate of approximately 93%, which is considered satisfactory for survey-based studies in social science research.

Descriptive statistics were used to present the general levels of the variables investigated in this study. As shown in Table 2, teachers' digital literacy obtained an average score of 3.26 (SD = 0.70), while technology integration recorded a mean score of 3.25 (SD = 0.66). Overall, the findings indicate that teachers in private universities in Shandong Province show a moderate level.

Table 2: Descriptive Statistics

Components	N	Mean	Std. Deviation	Skewness	Kurtosis
Digital Literacy	423.	3.26	0.70	0.334	-0.668
Technology Integration	423	3.25	0.66	0.478	-0.569

4.2. Correlation Analysis

Pearson product–moment correlation was employed to explore whether teachers' digital literacy is related to their level of technology integration. The results presented in Table 3 indicate a statistically significant positive relationship between the two variables ($r = .650$, $p < .01$). This finding implies that teachers who possess stronger digital literacy skills are more inclined to incorporate technological resources into their teaching practices.

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Furthermore, the relatively high correlation coefficient reflects a notable connection between these constructs. This suggests that digital literacy may play an important role in shaping teachers' technology integration behaviour. This result provides preliminary empirical evidence supporting the proposed relationship and justifies further examination through regression analysis.

This pattern may also be associated with the growing reliance on digital technologies in higher education, where teachers with stronger digital competencies are better positioned to adopt technology in instructional activities.

Table 3: Correlation between DLit and TI

Variable	Digital Literacy	Technology Integration
Digital Literacy	1	
Technology Integration	.650**	1

4.3. Measurement Model Evaluation

Prior to conducting hypothesis testing, the measurement properties of the constructs were examined to ensure that the indicators used in the study were reliable and valid. Consistent with recommended procedures in PLS-SEM analysis, the evaluation focused on three aspects: indicator reliability, internal consistency reliability, and convergent validity.

As shown in Table 4, the analysis shows that the factor loadings of the measurement items fall within acceptable limits, indicating that the indicators are appropriate measures of their respective constructs. Moreover, the composite reliability values for all constructs are higher than the commonly accepted threshold of 0.70, which reflects satisfactory internal consistency.

Convergent validity was assessed through the Average Variance Extracted (AVE). Table 4 also presents the AVE values for each construct, which are above 0.50, suggesting that the constructs account for more than half of the variance in their indicators. Taken together, these results indicate that the measurement model meets the required standards of reliability and convergent validity.

These results indicate that the measurement items used in this study are suitable for representing the theoretical constructs in the context of technology integration among teachers in private universities.

Table 4: Measurement Model Results

Construct	Dimention	Item	Outer Loading		CR((rho_c))		AVE	
DLit	TS	TS1	0.823	0.815	0.926	0.787	0.677	0.553
		TS2	0.838					
		TS3	0.821					
		TS4	0.823					
		TS5	0.818					
		TS6	0.816					
	CSs	CSs1	0.828	0.717	0.902		0.647	

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		CSs2	0.797				
		CSs3	0.804				
		CSs4	0.809				
		CSs5	0.784				
		SEs1	0.808				
		SEs2	0.806				
	SEs	SEs3	0.803	0.693	0.902	0.648	
		SEs4	0.809				
		SEs5	0.799				
		RC1	0.834				
		RC2	0.821				
	RC	RC3	0.842	0.657	0.898	0.688	
		RC4	0.821				
		PB1	0.835				
		PB2	0.817				
	PB	PB3	0.806	0.717	0.908	0.664	
		PB4	0.811				
		PB5	0.807				
		BB1	0.788				
TI		BB2	0.783		0.800		0.500
		BB3	0.795				
	BB	BB4	0.809	0.763	0.91	0.627	
		BB5	0.799				
		BB6	0.778				
		TSA1	0.824				
		TSA2	0.836				
	TSA	TSA3	0.822	0.688	0.91	0.668	
		TSA4	0.817				
		TSA5	0.788				

(Item Loadings, Composite Reliability, and AVE)

Discriminant validity was further assessed using the Fornell–Larcker criterion and the Heterotrait–Monotrait (HTMT) ratio to test construct distinctiveness. As shown in Tables 5 and 7, the analysis shows that the square root of AVE for each construct is higher than its correlations with other constructs. As presented in Tables 6 and 8, all HTMT values are below the recommended threshold. These results confirm that research constructs are empirically distinct from each other, supporting adequate discriminant validity.

Table 5: Fornell–Larcker Criterion for Digital Literacy Dimensions

Construct	CSs	SEs	TS
CSs	**0.805**		
SEs	0.305	**0.805**	
TS	0.36	0.332	**0.823**

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Table 6: HTMT Results for Digital Literacy Dimensions

Construct	Cognitive Skills	Social-Emotional Skills	Technical Skills
Cognitive Skills	—		
Social-Emotional Skills	0.348	—	
Technical Skills	0.406	0.375	—

Table 7: Fornell–Larcker Criterion for Technology Integration Dimensions

Construct	BB	PB	RC	TSA
BB	**0.792**			
PBclassroom	0.364	**0.815**		
RC	0.306	0.383	**0.83**	
TSA	0.369	0.281	0.31	**0.817**

Table 8: HTMT Results for Technology Integration Dimensions

Construct	BB	PB	RC	TSA
BB	—			
PB	0.413	—		
RC	0.352	0.443	—	
TSA	0.419	0.318	0.357	—

4.4. Structural Model Results

Structural model assessment was performed after the measurement model had met the required reliability and validity criteria. The purpose of this analysis was to examine how the proposed framework explains the relationship between digital literacy and technology integration.

For technology integration, the coefficient of determination (R^2) reached 0.426. This indicates that the predictors included in the model account for 42.6% of the variance in teachers' technology integration behaviour. In educational and social science research, this level of explained variance is generally interpreted as moderate.

Taken together, the findings indicate that the proposed model provides a meaningful explanation of teachers' technology integration practices in private universities in Shandong Province. The results also imply that the selected predictors capture important factors shaping teachers' adoption and use of technology in teaching activities.

4.5. Hypothesis Testing

To examine the proposed hypothesis, structural equation modeling was applied to assess the effect of digital literacy on teachers' technology integration. As shown in Table

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9, the results reveal a statistically significant positive relationship between the two constructs ($\beta = 0.653$, $t = 23.938$, $p < 0.001$).

Table 9: Hypothesis Testing Path Coefficients of the Structural Model

Path	Original sample (O)	Sample mean (M)	STDEV	t	p	R^2
DLit→ TI	0.653	0.653	0.027	23.938	0.000	0.426

The magnitude of the path coefficient suggests that teachers with stronger digital literacy are more inclined to incorporate digital technologies into their teaching activities. The large t-value also indicates that the relationship is statistically significant.

Furthermore, as reported in Table 9, the model explains 42.6% of the variance in technology integration ($R^2 = 0.426$), which represents a moderate level of explanatory power in educational research.

Taken together, these results support the proposed hypothesis and highlight the importance of digital literacy as a key factor influencing technology integration among teachers in private universities in China.

5. Discussion

The results suggest a close association between teachers' digital literacy and theirs' capacity to integrate technology into instructional activities. Teachers who possess stronger digital competencies appear more capable of incorporating digital tools into their teaching practices. The structural model results support this interpretation, revealing a significant positive relationship between digital literacy and technology integration ($\beta = 0.653$, $p < 0.001$).

This result aligns with previous research emphasizing the importance of teachers' digital competencies in supporting effective technology use in educational environments (Ng, 2012; Tondeur et al., 2017). Teachers with higher levels of digital literacy tend to demonstrate greater confidence in operating digital tools, evaluating online learning resources, and selecting appropriate technological solutions to support teaching and learning.

Moreover, digital literacy contributes to more meaningful use of technology beyond basic operational skills. When teachers possess adequate digital knowledge and skills, they are better positioned to design technology-supported learning activities, make effective use of digital platforms, and enhance the overall quality of instruction.

The findings also highlight the importance of strengthening digital literacy among university teachers. Higher education institutions may therefore consider providing structured training programmes and institutional support to help instructors further develop their digital competencies, which may ultimately encourage more effective technology integration in teaching practice.

This pattern may reflect the increasing importance of digital competencies in contemporary higher education environments, where effective teaching increasingly relies on the meaningful use of digital technologies.

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6. Conclusion

The results of this research reveal a clear connection between teachers' digital literacy and their ability to integrate technology into teaching practices in higher education. Teachers with stronger digital competencies appear better equipped to incorporate digital tools into their instructional activities. This outcome highlights the importance of strengthening teachers' digital capabilities within university environments.

Improving instructors digital literacy may therefore contribute to more effective use of technology in teaching. Higher education institutions can facilitate this process by providing targeted professional development programmes and sufficient institutional support to help teachers further develop their digital competencies.

While the present research offers insights into the role of digital literacy in technology integration, it mainly focuses on digital literacy as a key influencing factor. Future research may further explore this issue by examining additional variables, such as digital leadership, institutional support, and teachers' attitudes toward digital instruction. Investigating these factors together may help develop a more comprehensive understanding of technology integration in higher education.

This finding may reflect the increasing importance of digital competencies in contemporary higher education, where teaching practices are increasingly supported by digital technologies.

Ethics Approval and Consent to Participate

The researchers used the research ethics provided by the ethics Committee of the Faculty of Education and Sport Studies, Universiti Malaysia Sabah (UMS). Informed consent was obtained from all respondentswho were assured of their anonymity and the confidentiality of their responses. Participants were informed that they could withdraw from the study at any time without negative consequences.

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Conflict of Interest

The authors declare no conflict of Interest.

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