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RESEARCH ARTICLE

ICT Literacy, TPACK, and HOTS in Learning Quality of Indonesian Higher Educational System: Structural Model

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ABSTRACT

Nowadays, teachers are expected to enhance educational environments by actively supporting students' learning actions through innovative instruction that embraces technology. While most teachers aim to include some form of technology in their classes, there is a wide range in both the quantity and quality of such tools used. TPACK, ICT literacy, higher-order thinking skills (HOTS), and technical assistance are a few of these aspects. By investigating the link between TPACK, ICT literacy, and HOTS, this study hopes to contribute to the current body of information. Researchers in this study employed a relational screening strategy to look for links between TPACK, ICT literacy, and HOTS. Following the research concept, the data were analyzed using the Structural Equation Model (SEM) in AMOS Version 24.0. Undergraduates from Universitas Muhammadiyah Purwokerto, Indonesia took part in the research. The participants in this research were 1.893 students. Findings from this study lend credence to the idea that having a solid grasp of TPACK and being proficient with ICT can help students better manage their classrooms using HOTS. Thus, enhancing students' TPACK, and ICT literacy could be a key factor in ensuring that technology-enriched courses are effectively handled and that students achieve HOTS as a result of incorporating new technologies.

1. INTRODUCTION

The integration of technology into classrooms influences various aspects of learning and teaching environments, particularly in relation to ICT Literacy. According to Tseng et al. (2022), incorporating technology into instruction in a meaningful way requires effective ICT literacy. In the study conducted by Widiyawati et al. (2021), it was found that 19.5% of participants reported that the use of technology in the classroom complicates ICT literacy, presenting a significant barrier to the integration of technology in educational settings. It can be posited that when educators integrate technology into their instructional practices, they might require the development of their ICT literacy to effectively oversee the classroom (Ortiz et al., 2023). This indicates that literacy is influenced in distinct manners compared to traditional educational settings. A crucial element is the capacity to navigate environments that depend on information and communication technologies (Paidican & Arredondo, 2022). To address the challenges present in technologically enhanced classrooms, educators must develop a broader spectrum of ICT literacy.

As a result, when encountering challenges in technology-enhanced classrooms, educators may need to depend on the technology to address these issues. The application of higher-order thinking skills is closely associated with the utilization of ICT tools in problem-solving. Ning et al. (2024) define

HOTS as the acquisition of the information, skills, and attitudes necessary to employ ICT from a production-based perspective for addressing real-life problems. In ICT-enhanced classrooms, a positive and statistically significant relationship can be observed between students' higher-order thinking skills and their classroom management abilities. Integrating ICT literacy effectively is crucial for mitigating issues related to HOTS in technology-assisted courses. The qualification of educators is essential for the effective integration of information and communication technologies. Koehler et al. (2014) developed TPACK to identify the types of knowledge instructors require for the active integration of technology in their classrooms. It is reasonable to assert that teachers' TPACK is significantly enhanced when incorporating technology into the classroom. Adipati (2021) suggests that students with high TPACK are better prepared to tackle challenges associated with the integration of ICT literacy. The effective management of classrooms utilizing technology is positively and significantly correlated with ICT literacy and TPACK.

The main objective of this study is to address the gaps in the empirical evidence within the existing literature regarding the factors affecting higher-order thinking skills in technology-enhanced courses through structural equation modeling (SEM). Therefore, researchers examined the relationships between ICT literacy and the daily use of TPACK in technology-enriched classrooms, focusing on the quality of learning (Ortiz et al., 2023; Paidican & Arredondo, 2022). The literature search yielded no studies examining the relationship among ICT literacy, TPACK, and HOTS. This study seeks to contribute to the current literature by investigating the relationship among TPACK, literacy ICT, and HOTS.

LITERATURE REVIEW

ICT Literacy

Literacy in the use of ICT means being able to locate, assess, produce, and disseminate data. Computer literacy is the ability to work effectively in a digital environment by utilizing various electronic devices, software programs, and websites to accomplish tasks such as creating documents, organizing data, and collaborating with others (Elmy & Jizat, 2019). Important components of becoming literate in information and communication technologies: 1) abilities in using various types of hardware and software are what constitute technical competency; 2) managing information entails being able to find, sort, and assess data stored in digital formats; 3) competence in communicating and working together using electronic means, such as the Internet, email, social media, and other similar platforms; 4) use of ICT tools for problem-solving, data analysis, and decision-making includes critical thinking; and 5) Understanding concerns of digital privacy, safety, and responsible behavior online is essential for ethical and responsible use (Azari et al., 2023).

TPACK

Koehler et al. (2014) created a visual model of their TPACK framework, demonstrating the interaction among technological knowledge, pedagogical knowledge, and content knowledge. The three knowledge domains—technological, pedagogical, and content knowledge—are represented as three separate circles in their visual depiction. The convergence points create four overlapping areas, demonstrating the dynamic interaction among these essential aspects of teaching expertise. This representation serves as a significant visual emblem for the intricate integration of knowledge essential for proficient teaching in the digital era.

HOTS

Cognitive processes that transcend simple information memorization and recall are known as higher-order thinking skills. Analysis, evaluation, synthesis, and creation are all forms of more complicated thought that are required for these tasks. People with these abilities can think more critically, adapt their knowledge to different contexts, and come up with original solutions to issues (Pagina, 2019). Bloom's Taxonomy, a system for classifying cognitive abilities into varying degrees of complexity, is commonly linked with higher-order thinking. Among the more advanced categories in this taxonomy are: 1) analyzing anything means dissecting it into its constituent parts and seeing how they connect; 2) evaluation is the process of determining the merit or importance of a solution, argument, or concept by using predetermined criteria and standards; and 3) in synthesis, diverse parts come together to produce a new whole; this process can also lead to the development of novel concepts or approaches by drawing on existing body of knowledge. Because they foster analytical reasoning, problem-solving, and a more thorough grasp of ideas, higher-order thinking skills are highly prized in educational settings (Yunita et al., 2020).

The Link of ICT Literacy to TPACK

Achieving mastery over students is an essential initial step in developing sustainable learning and teaching strategies within the classroom (Huq et al., 2024). For effective learning and instruction, students need to engage in disruptive actions (Ayu & Asari, 2022). Kumala et al. (2022) assert that effective ICT literacy is essential for efficient student learning. It is posited that students monitor attention and performance in well-regulated classrooms, establish ground rules for student behavior, and consistently enforce these rules along with related matters (Ishartono et al., 2023). As classroom dynamics evolve, students may encounter novel challenges in sustaining order within the classroom. This results in new considerations that expand the skill set. An illustration of this is the application of ICT literacy in educational contexts to improve TPACK. The implementation of ICT literacy and TPACK in the classroom presents specific challenges (Saputra & Chaeruman, 2022). Students must embrace new challenges in TPACK to effectively adapt to technology-enhanced classrooms. This circumstance complicates TPACK issues in the classroom (Rahman et al., 2023). Consequently, it can be argued that ICT literacy, which is crucial for effective problem-solving across various contexts (Falloon, 2020), could prove instrumental in addressing emerging challenges related to ICT literacy stemming from the integration of TPACK (H1).

The Link of ICT Literacy to HOTS

Felix et al. (2024) argue that computer science encompasses all aspects of human behavior, from problem-solving to system creation, and hence is all-encompassing. After some time had passed, the idea was revised by Rahayu et al. (2021) to state that ICT literacy is the ability to think about problems in a way that a data processing agent can solve them. Definitions of ICT literacy have been proposed by a number of authors in the literature. Anwar et al. (2020) note that there is still no consensus on the scope and meaning of information and communication technology literacy. Various definitions have been put forward, such as algorithmic thinking, analysis, problem-solving, abstraction, debugging, and so on. The growing popularity of it can be attributed to the fact that it is part of a critical set of abilities that the next generation is anticipated to have (Widiyawati et al., 2021).

Having ICT literacy is crucial if we want to fully utilize the ubiquitous ICT tools that are available to us (Hasni et al., 2022). Conversely, the educational sector is one of the most active users of information and communication technology technologies. Their level of competence with information and communication technology has an effect on how we use technology in the classroom and on students' HOTS. Accordingly, a critical issue necessitating resolution is the non-proactive integration of ICT literacy into HOTS. Having the required information and communication technology literacy is essential for problem-solving. This literacy includes problem-solving, introspection, creativity, algorithmic thinking, abstracting, and debugging abilities. One may make the case that teachers' HOTS, or the usage of technology in the classroom, is related to how well they integrate technology into their lessons (H2).

The Link of TPACK to HOTS

Content knowledge (CK), pedagogical content knowledge (PCK), and pedagogical knowledge (PK) are all considered necessary abilities for competent educators to integrate technology effectively in the classroom. Gozali (2023) expanded this list by adding technological knowledge, which may have connections to the other three types of knowledge. Based on their research, Koehler et al. (2014) developed the theoretical framework of TPACK to describe the many forms of knowledge that students need to effectively incorporate technology into their lessons. In this theoretical framework, there are three main forms of knowledge: CK, PK, and TK. From these, four types of knowledge are derived: PCK, TCK, and TPACK, which stand for technical content knowledge and technological pedagogical knowledge, respectively. TPACK has multiple applications in education, including assessing students' HOTS to enhance the quality of learning (Nantha et al., 2024). TPACK is the gold standard for gauging how well educational institutions use technology in pedagogy and student learning. The reason is, that TPACK incorporates the finest information to support students' HOTS, which in turn allows for their effective implementation (Arya et al., 2020). Students TPACK are anticipated to face less challenges when it comes to integrating HOTS into their classrooms. One may argue that TPACK is related to HOTS, which involves actively incorporating technology into classrooms (H3).

METHODOLOGY

The study employed a quantitative survey research approach, applying multivariate data analysis to self-reported responses. The methodology encompasses participant selection, instrument development, and data analysis.

Research Model

The research model was developed based on the pertinent literature, as shown in Fig. 1. The study hypotheses that are addressed among the variables are depicted by one-way arrows.

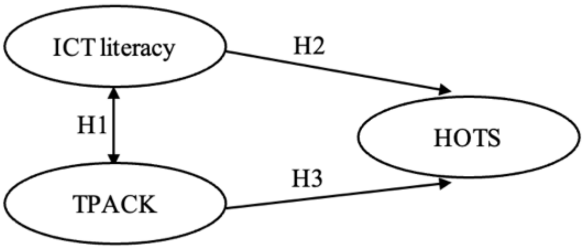

Figure 1. Conceptual Framework

According to Kline (2017), the Structural Equation Model (SEM) integrates the statistical frameworks of the measurement model's factor analysis and the structural model's regression. The structural and measurement models establish the relationship between the variables and the indicators. Both Exploratory Factor Analysis (EFA) and Confirmatory Factor Analysis (CFA) rely on statistics, while EFA is based on psychometrics and EFA is based on statistics (Ishtiaq, 2019). In the areas of self-management, leadership, and technical innovation, the research's structural model shows how problem-solving and cooperation interact with one another. A line with an arrow at both ends indicates a correlation, but only the end with the arrow indicates an effect. Two independent factors are considered in this study: ICT literacy, and TPACK. On the contrary, HOTS is the dependent factor for the model.

Study Groups

Participants in this study were students at Universitas Muhammadiyah Purwokerto, Indonesia. Table 1 shows that out of the 1.893 students who participated in the study, 56.20 percent were female and 43.80% were male. The majority of the participants (44.30%) hold in semester 4, while nearly a quarter have a semester 2, and the rest are in semester 6. Among the participants in the study, the majority live in urban areas (73.60%). Whereas the majority of students' access to the internet is in 3-5 hours per day (62.60%), continuing in less than 3 hours at 26.30%.

Table 1. The Demographic Profiles

Profiles	f	%
Gender		
Female	1063	56.20
Male	830	43.80
Semesters		
Semester 2	470	24.80
Semester 4	838	44.30
Semester 6	585	30.90
Location		
Urban	1393	73.60
Sub-urban	1390	26.40
Access of internet per day		
<3 hours	498	26.30
3 – 5 hours	1186	62.60
>5 hours	209	11.10

Instruments

Elmy and Jizat (2019) created ICT literacy (ICTLS), which consists of ten items across two domains. Here are the sub-dimensions of the scale: Personal literacy competence (PLC), and social literacy competence (SLC). Five things make up each subdimension. Of the total variation, 23,425% was explained by the PLC subdimension, and 24,531% by SLC. The calculated value for the internal consistency of the scale's subdimensions is 0.942. Figure 2 shows several instances of items related to the ICT literacy dimensions.
The Technological Pedagogical Content Knowledge Scale (TPACKS) was launched by Schmidt et al. (2009). This scale is comprised of 32 items that fall into seven categories: pedagogical knowledge (PK), technological knowledge (TK), content knowledge (CK), technological pedagogical knowledge (TPK), and technological content knowledge (TCK), pedagogical content knowledge (PCK), and technological pedagogical content knowledge (TPCK). Results for TPACKS and subdimensions' Cronbach Alpha reliability coefficients ranged from 0.74 to 0.92. Figure 2 displays multiple examples of items associated with the TPACK dimensions.

Eynde and Corte (2020) developed the HOTS Scale (HOTSS), which consists of 16 items across 3 domains. Here are the subdimensions: six questions for analyze (AN), five for evaluate (EV), and five for create (CR). 53.5% of the variance could be attributed to the scale, whereas the subdimensions' contributions ranged from 8.5 to 12.7%. Further, reliability coefficients for HOTSS and subdimensions were determined to be between 0.73 to 0.84 using the Cronbach Alpha method. Figure 2 shows several instances of items related to the HOTS dimensions.

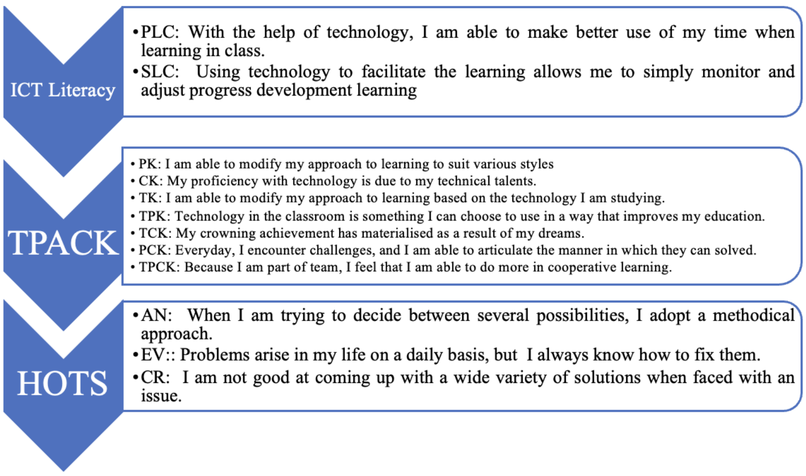

Figure 2. The Sample Items of the Instruments

Hypothesis Development

Examining the connection between ICT literacy, TPACK, and HOTS is the goal of this research. In addition, an explanation and prediction of the relationship between HOTS and other variables has been sought after in the form of a model. The following are the research hypotheses:

H1: Students' ICT literacy correlates positively with their TPACK.

H2: Students' ICT literacy is positively correlated with their HOTS.

H3: Students' TPACK is positively correlated with their HOTS.

Data Collections and Analysis

To acquire the information, we used a data collection instrument accessible online. Students who consented were emailed the link to the instrument. Before the procedure, participants were sent an information form outlining the study's goals and parameters. To protect the participants' anonymity, we have not asked for any identifying information, including their names or departments.

In keeping with the research concept, the collected data were analyzed using SEM (Bauldry, 2019). According to Bauldry (2019), the SEM is a statistical tool for investigating a possibly measurable path structure. You may measure the success of a phenomenon by using this model to see how strong the links are between the variables. This research investigates the connection between ICT literacy, TPACK, and HOTS in quality learning in the higher education system. Investigating reliability and any issues will be done by SEM later on.

When investigating the interplay of multiple variables, a structural equation model (SEM) proves to be an indispensable tool. Statistical empiricism, according to Romeo and Elleine (2022), is used by SEM to investigate a possible quantifiable path structure. By examining the consistency of relationships between variables, this model can determine how well a phenomenon is doing. We used AMOS Version 24.0 with a graphical user interface to analyze the data (Kline, 2017). Within SEM, four methods exist to alter Goodness of Fit (GOF). The goodness of fit is quantified by the GFI, whereas approximation error in a Chi-square test is measured by the RMSEA. An adequate developed model is indicated by GFI and AGFI values above 0.90, with 1 signifying the best conceivable result. A significance level > 3 is indicated by a chi-square/df > 3.0. According to Byrne (2019), the model satisfies the ideal criteria with an RMSEA of 0.08. After developing a model, it is examined to determine if the estimated parameters significantly deviate from zero at the 95% confidence level.

At the same time as it investigates the model's internal consistency, convergent validity, and discriminant validity (Bauldry, 2019), the research model also examines the model's parameters, such as the strength of the relationship between the SEM variables and the significance level (Ishtiaq, 2019). It is believed that internal consistency has been established as both the composite reliability and the Cronbach-Alpha reliability coefficient are more than 0.7 (Creswell, 2009). According to Kline (2017), all reliability coefficients have been determined to be greater than the default value of 0.70. Additionally, the AVE is greater than 0.50 (Byrne, 2019).

RESULTS

This section presents the model's findings concerning the study hypotheses.

Descriptive Analysis

The descriptive statistics pertaining to the variables are displayed in Table 2.

Table 2. The Descriptive Data Statistics

Scales	k*	Min	Max	Mean	M/k	SD
ICTLS	10	26.00	36.00	28.35	2.84	8.39
PLC	5	4.00	18.00	9.45	1.89	1.50
SLC	5	3.00	15.00	9.30	1.86	1.85
TPACKS	32	28.00	120.00	80.58	7.52	32.80
PK	5	7.00	30.00	34.80	6.96	7.04
TK	4	7.00	28.00	35.00	8.75	8.90
CK	4	8.00	38.00	29.58	7.40	7.42
TPK	4	7.00	30.00	32.80	8.20	7.89
TCK	5	6.00	40.00	34.50	6.90	7.35
PCK	5	7.00	27.00	33.50	6.70	5.90
TPCK	5	8.00	25.00	35.00	7.00	6.39
HOTSS	16	53.00	60.00	65.90	4.12	6.10
AN	6	6.00	20.00	18.40	3.07	3.01
EV	5	7.00	24.00	20.50	4.10	3.90
CR	5	8.00	24.00	18.50	3.70	3.50

Note: ICTLS: ICT literacy; PLC: personal literacy competence, SLC: social literacy competence; PK: pedagogical knowledge; TK: technological knowledge; CK: content knowledge; TPK: technological pedagogical knowledge; TCK: technological content knowledge; PCK: pedagogical content knowledge; TPCK: technological pedagogical content knowledge; AN: analyze; EV: evaluate; CR: create

The average ICT Literacy scale (ICTLS) score is 28.35, as indicated in Table 2. When compared to the other dimensions, the mean score for technological knowledge (TK) is above average (M/k=8.75). A mean score of 80.58 on the TPACKS scale was determined for the participants. The technological knowledge (TK) sub-dimension achieved the best result (M/k=8.75), while the pedagogical content knowledge (PCK) sub-dimension showed the worst score (M/k=6.70). The average score on the Higher Order Thinking Scale (HOTSS) is 65.90, as demonstrated in Table 2. The evaluation subdimension (EV) has the greatest mean score (M/k = 4.10) while the analysis subdimension (AN) has the lowest mean score (M/k = 3.07).

Measurement Model

The measuring model's appropriateness has been assessed using convergent validity. The following conditions must be met to achieve convergent validity: (1) The reliability of each item measure utilizing factor loading (>0.7), (2) the reliability of each construct's composite (>0.7), and (3) the accuracy of the mean (>0.5). The analysis's full findings are displayed in Table 3.

Table 3. The Measurement Model of Constructs Study

Construct	Factors	Factor loading	Mean	Standard deviation	Cronbach ' alpha	Composite reliability	Average variance extracted
ICT literacy	PLC	0.786	33.58	8.32	0.842	0.844	0.782
	SLC	0.743					
TPACK	PK	0.877	122.50	7.46	0.855	0.842	0.682
	TK	0.843					
	CK	0.766					
	TPK	0.785					
	TCK	0.822					
	PCK	0.954					
	TPCK	0.877					
HOTS	AN	0.735	85.35	8.65	0.892	0.942	0.744
	EV	0.877					
	CR	0.735					

Table 3 shows that when the results of the convergent validity analysis are examined, it appears that (1) all items have factor loadings greater than 0.7, (2) each item has composite reliability greater than 0.7, and (3) the AVE is greater than 0.5. That is, the measurement model seems to be consistent with convergent validity. Figures 3 to 5 impressed the measurement model analysis into the CFA Model. Whereas, the subdimensions' correlations concerning the measurement model's validity and reliability are shown in Table 4.

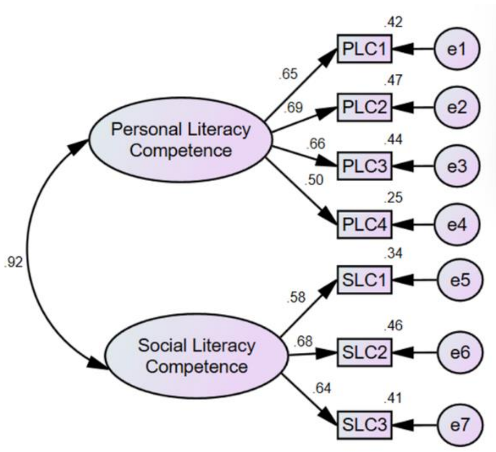

Figure 3. The Measurement Model of ICT Literacy

Table 4. Correlations for Each Construct

Construct	ICT literacy	TPACK	HOTS
ICT literacy	0.824		
TPACK	0.841	0.844	
HOTS	0.942	0.824	0.892

In Table 4, we can see that every correlation value has been below the diagonal. To determine the discriminant validity, we evaluated the correlation values with the square root of the AVE value.

These results show that the measurement model satisfies the criteria, including convergent and discriminant validity, as well as satisfactory reliability.

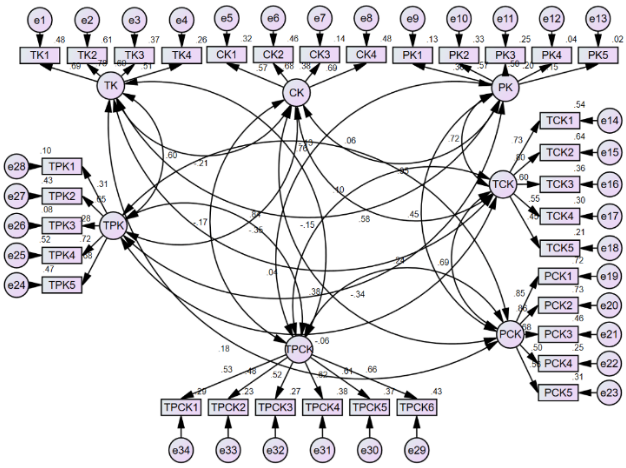

Figure 4. The Measurement Model of TPACK

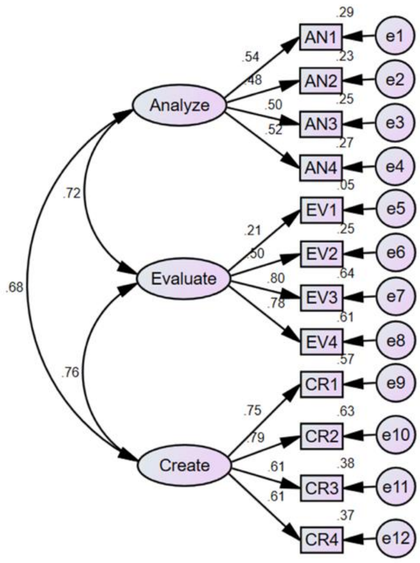

Figure 5. The Measurement Model of HOTS

Structural Equation Model

Supporting SEM are the three pillars of unidimensionality, validity, and reliability. Priority is given to unidimensionality. Before doing a structural model analysis, it is necessary to complete a pooled CFA to meet these three criteria. To attain unidimensionality, it is necessary to make sure that the loading factor for each item and dimension is more than 0.6. All three forms of validity—convergent, construct, and discriminant—can be proven with a CFA. Validity can be found in these forms. The measuring model is said to have convergent validity if and only if the AVE value can be used to validate all of its constituents. The acronym AVE represents the component's average value. When there were no items in the measurement model that evaluated the same two things, we concluded that the discrimination validity was high, and when the GOF was significant, we knew that the construct validity was high as well. Another criterion for discrimination validity is a correlation value below 0.4 between the two external constructs.

Figure 6 is used in the analysis to ascertain which model provides the most satisfactory explanation for the study's results. The first step is to check if the respondent's data is compatible with the proposed model using the fit index. For each of the three types of compatibility, there has to be a compatibility index that meets the minimal requirements. A Chi-Square/df value of 3.627, which is less than 5.0, and an RMSEA value of 0.073, which is less than 0.3, are given in Figure 6 as results of the structural equation analysis. With CFI at 0.936 and TLI at 0.909, all three fit indices are excellent.

Evaluating each coefficient is essential when the model is compatible with the response data. When the p-value is less than 0.05, we say that the hypothesis test was statistically significant. The test was also unidirectional as we knew the direction of the link was positive.

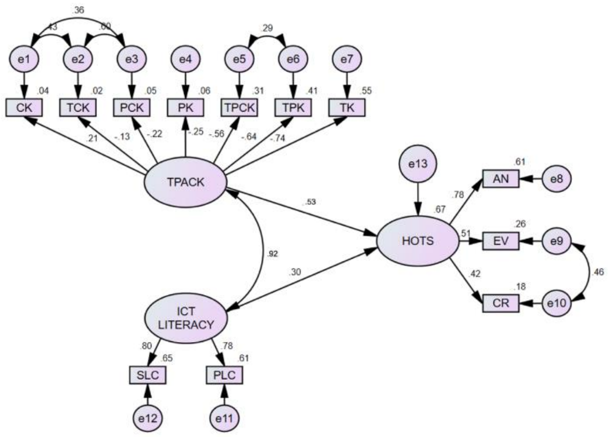

Figure 6. The Structural Model of The Constructs

The study considered three outward expressions of the parameters. The Standard Error (SE), Critical Ratio (CR), and significant value (p) ($p<0.001$) are all associated with the coefficient, which is also called the standard estimate or standard regression weight. When doing the hypothesis test, the coefficients p and are considered. Concerning numerical values, "little contribution" is defined as less than 0.10, "medium contribution" as between 0.10 and 0.50, and "high contribution" as greater than 0.50. Levels of insignificance might be negative or very low (less than 0.1). Thus, if the p-value is negative and less than 0.10, the null hypothesis will be rejected regardless of its significance. No matter how big the p-value is, this holds. When the p-value is smaller than 0.05, we say that the result is statistically significant. The extremely strong correlation between ICT literacy and TPACK is shown in Figure 6. With β= 0.92, the same conclusion can be derived about the relationship between TPACK and HOTS (β= 0.53). Despite their relationship, the link between ICT literacy and HOTS is medium contribution (β = 0.30). Thus, Table 5 contains all of the information regarding the correlations between the three constructs.

Table 5. The Structural Analysis of the Constructs

Sub-constructs			*β*	AVE	CR	p	Decision
ICTL	↔	TPACK	0.921	0.699	0.845	0.048	Significance
HOTS	←	TPACK	0.532	0.842	1.342	0.008	Significance
HOTS	←	ICTL	0.301	0.822	0.855	0.003	Significance
TK	←	TPACK	-0.743	0.674	2.909	***	No significance
CK	←	TPACK	0.212	0.584	1.975	0.005	Significance
PK	←	TPACK	-0.251	0.678	1.487	0.004	No significance
PCK	←	TPACK	-0.222	0.674	1.667	0.748	No significance
TCK	←	TPACK	-0.133	0.535	0.654	0.742	No significance
TPK	←	TPACK	-0.641	0.624	0.866	0.042	No significance
TPCK	←	TPACK	-0.562	0.645	0.834	0.037	No significance
SLC	←	ICTL	0.803	0.745	1.743	0.009	Significance
PLC	←	ICTL	0.782	0.677	3.574	***	Significance
AN	←	HOTS	0.783	0.564	2.631	***	Significance
EV	←	HOTS	0.514	-2.943	0.674	0.004	No significant
CR	←	HOTS	0.422	0.674	1.435	***	Significance

Table 5 indicates that there is no statistically significant correlation between TPACK and TK, PK, PCK, TCK, TPK, and TPCK (β=-0.743; negative; AVE = 0.674; CR = 2.909; p = 0.000; $p<0.001$), (β=-0.251; negative; AVE = 0.678; CR = 1.487; p = 0.004; $p<0.05$), (β=-0.222; negative; AVE = 0.674; CR = 1.667; p = 0.748; $p>0.05$), (β=-0.133; negative; AVE = 0.535; CR = 0.654; p = 0.742; $p>0.05$), (β=-0.641; negative; AVE = 0.624; CR = 0.866; p = 0.042; $p<0.05$), and (β=-0.562; negative; AVE = 0.645; p =

0.037; p<0.05). TPACK and CK are significantly affected by the remaining structures (β=0.212, AVE = 0.584, CR = 1.975, p = 0.005, p<0.05).

Furthermore, there was a statistically significant relationship between ICT literacy and the sub-factors, SLC (β=0.803; AVE = 0.745; CR = 1.743; p = 0.009; p<0.05) and PLC (β=0.782; AVE = 0.677; CR = 3.574; p = 0.000; p<0.001). Conversely, there was a statistically significant relationship between HOTS and CR (β=0.422; AVE = 0.674; CR = 0.674; p = 0.000; p<0.001). On the other hand, there was no significant relationship between HOTS and EV (β=0.514; AVE = -2.943, negative; CR = 1.435; p = 0.000; p<0.001).

Hypotheses Testing

The results of the analysis of all inner model route coefficients using the SEM procedure are shown in Table 6 and Figure 6. The results of the route coefficients of the research model are shown in Figure 3. By analyzing the route coefficients, we find that ICT literacy and TPACK are significant factors for measuring the HOTS of students in technology-enriched classrooms. Table 5 displays the results of these relative effects.

Table 6. The Hypotheses Result

Hypotheses	Path	Effect	Accept/reject
H1	ICTL-TPACK	0.92	Accept
H2	ICTL-HOTS	0.30	Accept
H3	TPACK-HOTS	0.53	Accept

This study has produced three research hypotheses to back up the notion that TPACK and ICT literacy have an impact on students' capacity to control their HOTS in enrichment classes. As shown in Table 5, all three of the study's hypotheses (H1 = 0.92, H2 = 0.30, and H3 = 0.53) were verified. The information supports the hypothesis that TPACK and ICT literacy affect HOTS. Moreover, it follows that TPACK is impacted by ICT literacy. Thus, every variable in the model has a large positive impact on HOTS.

DISCUSSION

In recent decades, the integration of technology in educational settings has transitioned from optional to essential. Despite its benefits for student learning experiences, issues related to higher-order thinking skills (HOTS) may emerge due to technology (Waluyo & Zamroni, 2023). Consequently, this study examines students' perceptions of their ICT literacy and TPACK concerning their abilities to effectively manage classrooms with higher-order thinking.

Maintaining students' higher-order thinking skills necessitates a positive attitude toward technology in the classroom (Hilmiatussadiah et al., 2024). Participation in seminars that impart new skills enhances students' comfort with technology in the classroom (Anud & Caro, 2023). Consequently, we hope that the data collected and analyzed by students in class will yield clearer insights. Students develop confidence in their skills as they apply their newly acquired technical knowledge and abilities in practical situations. Additionally, research conducted by Surahman et al. (2020) demonstrated that students who had previously completed challenging technological tasks were more likely to utilize technology effectively in the classroom to enhance learning and evaluate progress based on established criteria.

Previous studies have identified both advantages and disadvantages associated with the use of technology in educational settings. Research indicates that a majority of students acknowledge the significance of technology in facilitating access to pertinent resources (Rey Pelila et al., 2022; Sofeia et al., 2023). Wijnen et al. (2023) indicated that instructors can benefit from the various advantages of ICT literacy, which can be utilized in the classroom. The advantages encompass the topic's appeal, usability, multimodality, relevance, engagement, and significance. Students should be adequately prepared to integrate ICT literacy benefits into the classroom. TPACK is equally significant as other factors in the successful integration of technology into the classroom. The proficiency of students in technology directly correlates with the effectiveness of digital integration initiatives (Joshua & Mohamad, 2021).

The findings of the study substantiate the hypothesis that ICT literacy enhances TPACK in educational environments (H1). Students with higher ICT literacy may hold a more favorable view of their peers' abilities to manage technology in the classroom while utilizing TPACK. The relationship among ICT literacy, TPACK, and the formulation of optimal solutions to specific problems elucidates this finding. A student requires comprehensive knowledge of the educational environment to effectively manage their cognitive processes in the classroom. They must also identify potential issues, assess their severity, and develop strategies to address them (Apriani & Harmi, 2022). Establishing a link between the two necessitates comprehension of debugging, an essential skill in ICT literacy, as well as the operational and technological challenges that students present in the classroom. Debugging a system involves the ability to identify and rectify faults (Widajati & Mahmudah, 2023). Every aspect of a classroom can be regarded as part of a technological system. Students' debugging skills, integral to ICT literacy, are essential for identifying issues and formulating effective solutions through TPACK (Sarumaha, 2020).

The participants' ICT literacy positively influenced their HOTS (H2). The model demonstrates a significant effect of ICT literacy on HOTS. It is reasonable to conclude that participants' ICT literacy significantly influences their higher-order thinking skills. Rukmana and Handayani (2020) identified a significant correlation between ICT literacy and HOTS. It follows that individuals skilled in ICT literacy are likely to possess a strong understanding of higher-order thinking skills. Additionally, there is research examining the relationship between ICT literacy and higher-order thinking skills (HOTS) (Annida et al., 2023; Kadıoğlu-Akbulut et al., 2023), as indicated in the literature review. It is reasonable to conclude that ICT and HOTS are significantly related.

The findings indicate that educators' TPACK has a significant effect on HOTS (H3). Instructors' TPACK is instrumental in identifying potential issues in technology-enhanced classrooms and mitigating their proliferation through critical thinking. This finding is supported by Joseph et al. (2022) and Paidican & Arredondo (2022), who demonstrated that teachers possessing higher levels of TPACK are more effective in addressing the challenges associated with the integration of HOTS processes in the classroom. Students proficient in TPACK are better equipped to integrate technology into their lessons and can efficiently address any issues that may occur. Classroom issues stemming from the integration of technology and higher-order thinking processes can largely be attributed to insufficient expertise and experience in this domain (Ishartono et al., 2023). Huq et al. (2024) identified a relationship between the effective application of TPACK and HOTS in classroom activities associated with teaching and learning.

CONCLUSION

This paper presents three key contributions derived from the significant pathways linking antecedent variables to the HOTS framework. The significant explanatory power of digital natives concerning pedagogical knowledge suggests an advantage in their ability to translate digital materials into effective lesson delivery. Policy guidelines for the digitalization of materials must focus on intervening factors such as digital nativity and cyber-wellness. Educational leaders may prioritize capacity building for basic education teachers to improve their confidence in developing digital materials, particularly for those who are not digital natives. Secondly, the significant explanatory power of TPACK about HOTS supports findings from emerging literature discussed in this paper, which is situated within the context of a developing economy during the complexities of the post-pandemic new normal. This finding represents a significant contribution, particularly as the basic education systems in developing economies were most adversely impacted by the disruptions caused by the pandemic. Consequently, statistical evidence suggests that teachers' pedagogical content knowledge was adapted to facilitate technological integration during the sudden transition. Finally, the significant explanatory power of TPACK to HOTS warrants discussion, as even in economically challenged countries such as the Philippines, teachers demonstrate resilience by adapting their expertise to facilitate a more technology-enhanced delivery of classes.

Subsequently, the study concludes that enhanced HOTS contribute positively to technology-based ICT literacy and TPACK systems in classrooms. Students who perform better on the HOTS may perceive the quality of learning as effective in managing the class's technology use. This finding can be elucidated by examining the relationship between higher-order thinking skills and the production of superior solutions to specific problems. An effective classroom manager must possess a comprehensive understanding of higher-order thinking environments. They must be capable of identifying potential issues proactively, assessing their severity and devising appropriate solutions.

Implications

Theoretically and pragmatically, this study should add to the existing literature on HOTS. Finding a model that describes skills in technology-based courses is one of the most important theoretical achievements of this research. When it comes to estimating HOTS, this model uses ICT literacy and TPACK. Based on these results, ICT literacy and TPACK may serve as a useful predictor of HOTS.

Results demonstrate that ICT literacy and TPACK significantly predict HOTS. Therefore, it is reasonable to assume that improving students' ICT literacy and TPACK may play a significant role in making sure that technology is well-managed and that students benefit from the integration of new technologies. Given the close association between ICT and TPACK, it could be reasonable to assume that activities aimed at enhancing students' technology integration skills through the quality of learning of HOTS will provide substantial results in educational contexts. A higher-thinker educator is likely to find effective ways to handle disruptive students if this scenario plays out as expected.

Limitations and Suggestions

Using a self-reflective data collection instrument to acquire data on teachers' opinions of classroom management in technology-enriched classrooms is one limitation of this research. What this suggests is that the way teachers see the current situation in technology-enhanced classrooms could not be reflective of reality. Consequently, research based on teacher and student opinions, in addition to self-reflective data collection instruments, can be conducted to identify the elements influencing the perceptions of quality of learning skills in technology classrooms. This could give light on the elements that influence students' skills to maintain order in the classroom as well as how to identify those students with the most promising practices.

The study's findings reveal how ICT literacy and TPACK proportionally affect HOTS. Therefore, to improve the TPACK and classroom management abilities of both future and current students, in-service training programs can be designed to focus on the development of HOTS. The study also has a small sample size and only covers a small geographic region, which are both limitations. Further in-depth understanding of the interactions between ICT literacy, TPACK, and HOTS can be achieved through the organization of mixed- or quantitative-method research with larger participation.

As a result, studies can be carried out to clarify how the structure of the quality of learning has evolved across these classes. Furthermore, it can be asserted that there will be significant consequences from investigating the function of ICT literacy and TPACK in resolving novel issues with HOTS that arise concurrently with lessons.

AUTHORS' CONTRIBUTIONS

WNY: Conceptualization, design, analysis, writing, final approval. SA: Editing/reviewing, material support, supervision. ES: data acquisition, statistical analysis, securing funding

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