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DEVELOPMENT AND VALIDATION OF THE INSTRUMENT FOR MEASURING DIGITAL LEARNING ORGANIZATION CULTURE

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ABSTRACT
Digital transformation has had a profound impact on the education sector. This scenario drives dynamic changes that require teachers to continuously learn and adapt within a culture of a learning organization (LO). Although the concept of LO has been introduced for centuries, its application in the context of digital educational transformation remains underexplored. Thus, there is a gap in the need for valid instruments to measure learning organization culture through digital platforms, which can be adapted from existing instruments. The instrument was adapted from the School Learning Organization Questionnaire (SLOQ) and refined to integrate the digital elements. This article reports the validation procedure for the Digital Learning Organization Instrument for Schools (DigiLOIS), a 19-item questionnaire. Data were collected from 200 secondary school teachers for an Exploratory Factor Analysis (EFA) and from 373 coherent respondents for a Confirmatory Factor Analysis (CFA) in one state in Malaysia. Data analysis was conducted using SPSS 29.0 for EFA and AMOS 29.0 for CFA. In this study, a measurement tool of DigiLOIS instrument was established, comprising three dimensions: Individual Digital Learning (IDL), Team Digital Learning (TDL), and Organizational Digital Learning (ODL). In practice, this study has proposed robust psychometric tools for policymakers, school leaders, and researchers to enhance the culture of digital learning organization (DLO) within the school environment.

1. INTRODUCTION

The world of education is constantly changing and undergoing a transformation process (Ravn et al., 2022). In line with the era of the Fifth Industrial Revolution (IR5.0) and Sustainable Development Goal 4 (SDG4), education has undergone significant changes, particularly through technological advancements and digital system enhancements (UNSD, 2024; KPM, 2024). On a global scale, it is widely debated that the challenges faced by the education sector are becoming increasingly complex due to the dynamic process of change (Olasoji, 2024). As such, a lifelong learning culture has become essential at the organizational, team, and individual levels to develop teachers' thinking skills, enabling them to be more creative and innovative. This concept was rooted in Senge's ideas (Senge, 1990, 1994, 1996). Bandura's Social Cognitive Theory (SCT) is seen as the best theory to explain the learning process occurs within the interaction between environmental factors, personal factors and behavioral factors (Bandura, 1986). For example, some scholars have provided evidence that teachers must continuously engage in the learning process to adapt to changes (Alexandro & Basrowi, 2024; Alzadjali et al., 2023; Bandura, 2001). Failure to do so may render teachers' roles in schools ineffective (Asbari, 2024; Silins & Mulford, 2004). Similarly, some scholars link implicit knowledge sharing and professional learning communities to LO theory as a derivative of it (Admiraal et al., 2021; Chughtai et al., 2023; Ismail et al., 2022; Kin & Kareem, 2021; Hendrickx et al., 2025). Their findings emphasized that collaborative learning and organizational support are significant for active teacher engagement in professional development.

In Malaysia, the Digital Education Policy (*Dasar Pendidikan Digital*, DPD) has been formulated to enhance the nation's proficiency in digital technology (KPM 2021). Additionally, the policy aims to strengthen teachers' digital competency by integrating it into strategic initiatives that enhance teacher effectiveness in schools. This aligns with the Technological Pedagogical Content Knowledge (TPACK) framework, which requires teachers to master the technology, pedagogy, and content knowledge (Abbitt, 2011; Schmid et al., 2024). A learning organization (LO) is seen as a way forward to encourage teachers to be more engaged in continuous learning (Comyn, 2018; Matsumoto-Royo, 2021).

The existing LO model was built upon an era where the digital platform was not yet in the spotlight (Marsick & Watkins, 2003; Yang et al., 2004; Tengku-Ariffin, 2010). Although it appears robust enough and has been

tested in various contexts, it currently lacks the critical essence of learning. Nowadays, learning occurs through chat threads, within an LMS system, via AI platforms, and similar channels (Ifenthaler et al., 2021; Müller & Leyer, 2023). Therefore, there is a dire need to revisit the existing LO instrument and, without losing the strong foundation, propose a short version that integrates digital elements. Thus, in this study, based on the items and dimensions of the LO measurement proposed by previous scholars, a new instrument to measure LO in the digital environment has been developed and validated (Marsick & Watkins, 2003; Yang et al., 2004; Tengku-Ariffin, 2010). This new instrument, the Digital Learning Organization Instrument for Schools (DigiLOIS), provides a robust measurement tool for researchers, school leaders, and policymakers of the Digital Learning Organization (DLO) in the new digital era of the education system. Overall, this instrument contributes to novelty in both theoretical and practical fields by featuring the sharpest dataset, robust procedures, and stronger discussion points, as it is rooted in Senge's concept of developing human resources (Senge, 1990, 1994, 1996). In this regard, the DigiLOIS instrument can emphasize the learning organization on digital platforms and be adapted to both the local Malaysian and global contexts.

2. LITERATURE REVIEW

2.1 The Concept of Learning Organization

The concept for the Learning Organization (LO) was first introduced in *The Fifth Discipline: The Art and Practice of the Learning Organization* by Senge (1994). In this book, five core disciplines are outlined: (i) systems thinking, (ii) personal mastery, (iii) mental models, (iv) shared vision, and (v) team learning. Broadly, LO is characterized by continuous, formal, and informal learning processes within the organization's members to enhance performance and productivity (Senge, 1990; Springer et al., 2024). Such continuous learning fosters synergy within the organization, motivating its members to expand their knowledge and skills (Alzadjali et al., 2023; Ibas, 2015). For example, teachers are involved in professional learning communities (PLCs), panel discussions, peer coaching, workshops and training, and action research projects (Admiraal et al., 2021; Al-shammari, 2020; Hendrickx et al., 2025).

Based on Senge's foundation, several scholars subsequently operationalized the LO concept into a more measurable framework (Marsick & Watkins, 2003; Yang et al., 2004; Tengku-Ariffin, 2010). Among the several models of LO proposed, the framework developed by Watkins and Marsick (2003) remains the most prominent (Marsick &Watkins, 2003). The original idea proposed by Watkins and Marsick encompasses three levels: the individual level, which includes (i) continuous learning as well as (ii) dialogue and inquiry; the team level, which focuses on fostering team learning; and the organisational level, which comprises (i) systems that support learning, (ii) empowerment, (iii) networking and connections, and (iv) strategic leadership for learning (Marsick & Watkins, 2003). Subsequently, Yang et al. (2004) and Tengku-Ariffin (2010) supported Marsick and Watkins's framework, asserting that its seven dimensions facilitate learning at the individual, team, and organizational levels.

Initially, this concept was mainly applied in profit-driven sectors such as corporate management, business, and industry (Marsick & Watkins, 1999; Senge, 1990; Springmier et al., 2024; Yang et al., 2004). The LO model has been widely studied across various contexts and countries. For example, in Asia, LO within the human resource context in South Korea and China has been explored for its application among employers in various industries (Song et al., 2009; Song et al., 2011; Li & Lu, 2007). In the Middle East, some scholars employed the DLOQ to examine LO in Lebanon's banking and information technology sectors in Saudi Arabia (Alshammari, 2020; Jamali & Sidani, 2008). Similarly, researchers from India explored the LO concept within the Indian context (Awasthy & Gupta, 2012; Tandon, 2020; Dahanayake & Gamlath, 2013). In Malaysia, a study on LO in the school context found that it was introduced as a culture to enhance teachers' knowledge (Ibas, 2015; Ishak, 2020; Kullan & Mansor, 2020; Tengku-Ariffin, 2010).

Collectively, these studies suggest that the DLOQ is the most widely used instrument for assessing LO practices. By fostering learning at the individual, team, and organizational levels, the LO framework provides a comprehensive approach for understanding how learning is embedded within the organization.

2.2 The Concept of Digital Learning Organization (DLO)

Based on the Learning Organization (LO) concept, the implementation of the Digital Learning Organization (DLO) has led to a significant shift by leveraging digital adoption, including tools, systems, and platforms (Alzadjali et al., 2023; Ifentheler et al., 2021; Junus & Sulaeman, 2021). Therefore, this article examines the learning culture in schools to emphasize the concept of a Learning Organization through digital platforms. A digital learning organization leverages a range of platforms, including communication tools, video conferencing tools, collaboration and content sharing tools, a learning management system (LMS), and a Professional Learning Community (PLC) platform (Junus & Sulaeman, 2021; Luna et al., 2022; Springer et al., 2024; Tai & Omar, 2021).

These platforms have become increasingly prominent in the current educational landscape, offering significant potential for enhancing teacher effectiveness (Amhag et al., 2019; Junus & Sulaeman, 2021). For example, traditional face-to-face meetings can be replaced with communication tools like WhatsApp, Telegram, Google Chat, and Microsoft Teams Chat. While Google Meet, Zoom, Microsoft Teams, and Webex could replace the gathering methods for sharing sessions. In addition, a paperless scenario can replace knowledge management and sharing among teachers in groups or within an organization using Google Drive, OneDrive, and Dropbox.

Learning Management Systems such as Google Classroom, Moodle, and Canva are widely used to facilitate digital learning and support teacher collaboration. Moreover, collaboration among teachers for content creation can be facilitated using tools such as Google Workspace (Docs, Sheets, and Slides), Microsoft 365 (Word, Excel, and PowerPoint), Padlet, and Miro. Finally, a PLC is one of the activities in LO that can be conducted digitally. For instance, teachers use Facebook groups to create learning communities (Schmid & Hassan, 2024). In Individual Digital Learning, dialogue and inquiry enable teachers to share best practices that were previously executed through face-to-face PLC meetings in virtual spaces such as WhatsApp groups, Telegram groups, and live webinars. In team-based learning, digital collaboration platforms such as Google Classroom and Microsoft Teams have significantly enhanced the way teachers organize classes, plan lessons, share resources, and collaborate across schools (Uaidullakyzy et al., 2022). The team's reliance on printed materials and in-person meetings previously limited real-time engagement. Additionally, the empowerment in DLO is enhanced through self-paced learning, digital certifications, and gamified training on DELIMa. Empowerment enables teachers to take charge of their professional development, rather than relying exclusively on hierarchical training systems (Junus & Sulaeman, 2021).

At the organizational level of digital learning, the digital network system and strategic leadership have also impacted the teacher learning process (Sousa & Rosha, 2019). Nowadays, professional learning groups, AI-driven insights, and digital networking among teachers exist without geographical boundaries. In line with this, leadership development, which once relied on face-to-face mentoring, has shifted to a virtual model, with strong leadership support that encourages learning through digital platforms (Aleesa, 2021). Thus, this shift highlights the crucial role digital technologies play in fostering leadership and lifelong learning.

In conclusion, DLO is an innovative concept that leverages digital platforms, tools, and systems to enhance teachers' learning (Schmid & Hassan, 2024). In this study, DLO is defined as a culture of knowledge that supports continuous learning at the individual, team, and organizational levels in a digital environment.

3 RESEARCH METHOD

This study employed a quantitative, cross-sectional survey. This design is suitable for examining perceptions across a broad population and allows for generalization to similar contexts (Hair et al., 2019). As suggested by Sekaran and Bougie (2016), a multi-stage sampling technique was employed in three phases. This method was chosen to ensure that respondents from different zones across the country had an equal chance of being selected in the random sampling process. In the first stage, cluster sampling was used to randomly choose one zone from the four zones identified by local geographical divisions: the west coast, east coast, northern, and southern zones of Peninsular Malaysia. Once the zone was identified, a state within it was randomly selected. The second stage involved stratified sampling, in which teachers were stratified by district within the selected state, and samples were selected proportionally to each district's teacher population. A few schools within each district were then selected, and teachers within those schools were identified through systematic random sampling. This structured multi-stage sampling approach is recommended to reduce sampling bias and ultimately yield a balanced group of respondents representative of the population under study (Hair et al., 2019). The targeted population consisted of 179,750 secondary school teachers in Malaysia, and based on Krejcie and Morgan's table, the total sample size needed was 384 teachers (Krejcie & Morgan, 1920). However, after screening the data, only 373 data points were usable for analysis using Exploratory Factor Analysis (EFA) and Confirmatory Factor Analysis (CFA) (Hair et al., 2019). Through this procedure, 200 samples of the dataset were used for EFA, and 373 samples of the dataset were used for CFA.

3.1 Instruments

The study adopted the original DLOQ established by Marsick and Watkins (1996; 1999; 2003), comprising 43 items and forming a lengthy questionnaire instrument. The instrument serves as the primary tool for assessing LO in business enterprises (Admiraal et al., 2021; Ismail et al., 2022). Multiple researchers across sectors, including banking, the military, business, and education, have used the DLOQ instrument to measure LO over the years (Comyn, 2018; Dahanayake & Gamlath, 2013; Marsick & Watkins, 2003; Matsumoto-Royo et al., 2021; Yang et al., 2004).

Yang et al. (2004) presented a condensed version of the DLOQ, reducing it to 21 items while retaining its original seven dimensions. Grounded in this approach, Tengku Ariffin (2010) developed the School as Learning Organization Questionnaire (SLOQ), adapting the shortened DLOQ proposed by Yang et al. (2004) for the Malaysian secondary school context. In this adaptation, Tengku Ariffin (2010) modified 11 of the original 21 items, incorporated 8 items from the extended version of the DLOQ (Marsick & Watkins, 1996), and added 2 new items to better align the instrument with the cultural and organizational characteristics of Malaysian schools.

The present study further advances this line of instrument development by adapting SLOQ for the digital age. The Digital Learning Organization Instrument for School (DigiLOIS) removed two items due to low factor loadings during validation, resulting in a final instrument comprising 19 items. Additionally, the instrument incorporates elements of digital learning practices to accommodate the technology-driven professional learning of the contemporary era. This research used a five-point Likert scale (1 = Strongly Disagree to 5 = Strongly Agree) in its Malay-language version to ensure linguistic and cultural appropriateness.

3.2 Data Analysis

3.2.1 Content Validity of Item.

In this study, the content validity of the initial 21 items was assessed by a panel of five experts with more than ten years of relevant experience (Hair et al., 2019). Experts rated the clarity and relevance of each item using a four-point scale. The Content Validity Ratio (CVR) and Content Validity Index (CVI), calculated using recommendations from the Lawshe method (Lawshe, 1975). The content validity procedure was utilized to evaluate how well the questionnaire items measure the LO. Davis (1992) stated that a new measurement tool development requires a minimum CVI of 0.8; however, some experts suggest 0.78 or higher when panel experts exceed (Davis, 1992; Rubio et al., 2003). These results provided an initial screening before EFA and CFA were executed.

3.2.2 Exploratory Factor Analysis (EFA)

EFA was performed using SPSS version 29.0 on data collected from 200 secondary school teachers. Sampling adequacy was assessed using the Kaiser-Meyer-Olkin (KMO) measure, Bartlett's Test of Sphericity, and the Total Variance Explained exceeded 60% (Hair et al., 2019). Factor extraction was conducted using Principal Component Analysis (PCA) with Varimax rotation, retaining items with loadings of 0.60 or above. Items with low loadings or high cross-loadings were removed.

3.2.3 Confirmatory Factor Analysis (CFA)

CFA was conducted using AMOS version 29.0 with a sample of 373 teachers. Model fit was assessed using several indices: $\chi 2$ (≤ 3.00), Comparative Fit Index (CFI ≥ 0.90), Tucker-Lewis Index (TLI ≥ 0.90), and Root Mean Square Error of Approximation (RMSEA ≤ 0.08). Convergent validity was evaluated using standardized factor loadings, Composite Reliability (CR ≥ 0.70), and Average Variance Extracted (AVE ≥ 0.50). A Second-order CFA was then conducted to confirm that the three dimensions formed the higher-order construct of DLO.

4 FINDINGS

4.1 Content Validity

The measurement tool in this study yields a CVR of 0.80-1.00. The overall CVI was 0.92, indicating strong agreement among the experts on the 21 items in the initial pool. The questionnaire items meet the minimum threshold of 0.8 set by methodological scholars (Davis, 1992; Polit et al., 2007).

4.2 Exploratory Factor Analysis (EFA).

EFA results supported a three-factor structure, with two items removed due to low factor loadings, resulting in a final instrument comprising 19 items. To determine the appropriate factors, this study used Principal Component Analysis and Varimax with Kaiser Normalization rotation as part of the EFA procedure (Hair et al., 2019). The Measure of Sampling Adequacy (MSA) or KMO value was 0.884, exceeding the minimum value of 0.6. The Bartlett's Test value was significant (p-value < 0.05). The factor loadings values for all items in the DLO instrument were satisfactory, ranging from 0.620 to 0.818, indicating that all items were suitable for further EFA analysis. Table 1 below shows the total variance explained in the EFA procedure. According to statistical experts, the total variance explained in the table should exceed 60% (Hair et al., 2019). Therefore, the total variance explained in this study was 74.353%, exceeding the minimum requirement.

4.3 Internal Reliability of Instrument

The instrument's internal reliability was assessed through a pilot test, which yielded a Cronbach's alpha ($\alpha = 0.933$), considered excellent per Hair et al. (2019). Values between 0.60 and 0.70 are acceptable and reasonable, values between 0.80 and 0.90 are better, and values between 0.90 and 0.94 are considered excellent. The internal reliability is shown in Table 1.

Table 1. The reliability of DLO by dimensions

Dimension	Value of Cronbach Alpha (α)	Number of Items
Individual Digital Learning	0.947	7
Team Digital Learning	0.934	7
Organizational Digital Learning	0.907	5
Total Value of Cronbach Alpha (α)	0.933	19

The EFA result is shown in Table 2. The Three-branched factor was gained, with 2 items removed. Finally, 19 items remain in this process.

Table 2. Extracted items from EFA for Digital Learning Organizations (DLO) construct

Item	Statement of Item	Extraction			Status
DLO1	Teachers consistently support one another in learning through digital facilities.	.747			Proceed
DLO2	Teachers are given time to enhance their skills through digital facilities.	.765			Proceed
DLO3	Recognition is given to teachers who practice continuous learning through digital facilities.	.818			Proceed

DLO4	Teachers feel comfortable providing open feedback to one another through online platforms (e.g., WhatsApp, email, online forums, Google Meet, etc.).	.813			Proceed
DLO5	When teachers express their opinions during online meetings, they seek input from other teachers.	.787			Proceed
DLO6	All teachers are given opportunities to ask questions or express their opinions, either face-to-face or online.	.785			Proceed
DLO7	Teachers can collaborate in virtual teams to achieve school goals.	.658			Proceed
DLO8	Teachers frequently discuss and make joint decisions with their team members using digital applications (e.g., Google Meet, WhatsApp, Telegram, email, Webex, etc.).		.450		Deleted
DLO9	Teachers consistently complete assigned tasks on digital platforms.		.718		Proceed
DLO10	Teachers can effectively express their opinions, complaints, or information through various online platforms.		.764		Proceed
DLO11	Teachers can easily obtain the necessary information at any time through digital technology.		.737		Proceed
DLO12	Teachers share knowledge and skills using digital technology.		.685		Proceed
DLO13	Administrators highly value teachers' initiatives to enhance their knowledge through digital technology.		.652		Proceed
DLO14	Administrators at my school grant teachers the autonomy to use online resources to carry out their tasks.		.638		Proceed
DLO15	Administrators at my school grant teachers autonomy to select appropriate digital technologies for teaching.		.537		Deleted
DLO16	Stakeholders are invited to provide input on the implementation of digital technology in the school.		.620		Proceed
DLO17	Teachers find it easier to network with the external community through digital platforms compared to face-to-face interactions.			.658	Proceed
DLO18	School administrators encourage teachers to build external networks by utilizing digital platforms.			.717	Proceed
DLO19	The school principal practices instructional leadership by providing virtual coaching (via digital applications) to support teachers' teaching performance.			.804	Proceed
DLO20	The school principal uses online platforms to share the latest information with teachers.			.768	Proceed
DLO21	The school principal supports teacher professional development programs that adopt digital approaches.			.814	Proceed
Kaiser-Meyer-Olkin Measure of Sampling Adequacy		0.884			
Bartlett's Test		1466.963			
Percentage of Variance Explained		74.353%			

4.4 Confirmatory Factor Analysis (CFA)

The Digital Learning Organization (DLO) is a second-order construct comprising three dimensions, as presented in Figure 1. In this figure, the CFA procedure shows the overall model fit indices for the construct, the factor loadings for each dimension, and the factor loadings for individual items. Therefore, based on the results in Figure 1, the validity and reliability of the DLO can be asserted in the next step of analysis.

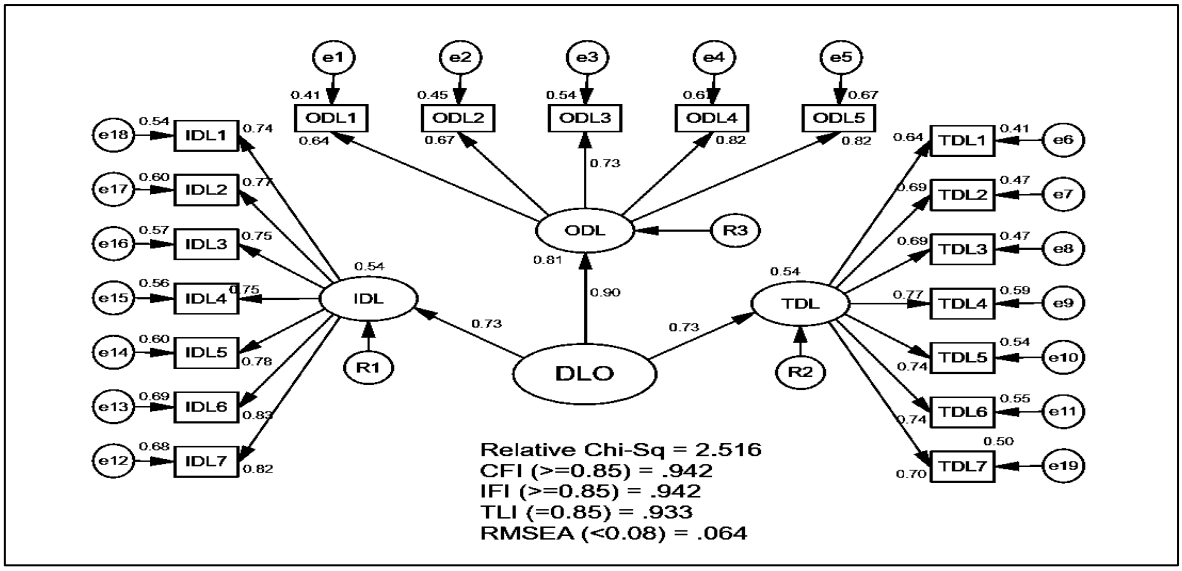

Figure 1: The Measurement Model of DLO

Based on the CFA analysis, DLO showed that the measurement model met the minimum threshold for model indices. This conclusion can be represented by the acceptable fit measurement, with RMSEA = 0.064, CFI = 0.942, TLI = 0.942, and Chisq/df = 2.516. All items in the model exhibited factor loadings exceeding 0.60. Thus, no items were removed from the construct.
Subsequently, the procedure was proceeded with the evaluation of construct validity, convergent validity, and composite validity. To assess the construct validity, model fit indices were extracted through the CFA procedure. Therefore, the measurement model for this construct met the requirement for construct validity (Song et al., 2009).

Table 3. Assessment of AVE and CR for convergent validity for DLO

Construct/Dimension	**CR (> 0.6)**	**AVE (> 0.5)**
Digital Learning Organization (DLO)	.832	.625
Individual Digital Learning (IDL)	.915	.605
Team-based Digital Learning (TDL)	.877	.506
Organizational Digital Learning (ODL)	.857	.547

For the assessment of Convergent Validity, it refers to the value of Average Variance Extracted (AVE) and Composite Reliability (CR) for the construct and its dimensions. Based on Table 3, the values exceed the thresholds of 0.50 and 0.60, respectively. Therefore, it can be concluded that both convergent validity and composite validity were achieved (Hair et al., 2019).

5 DISCUSSIONS

This study developed and validated the DLO Instrument for School (DigiLOIS), providing a robust psychometric reliability tool that aligns with the LO framework. Using a two-step process that combined EFA and CFA using two separate samples, DigiLOIS emerged as a 19-item, three-dimensional, and second-order structure, comprising Individual Digital Learning (IDL), Team-based Digital Learning (TDL), and Organizational Digital Learning (ODL). This framework confirmed DLO as a valid and reliable instrument for measuring the continuous learning culture through digital platforms in schools. The comparison of the LO and DLO models is shown in Table 4.

Table 4. *Comparison of the Traditional LO Model and the DLO Model*

Traditional concept of LO		**New concept of DLO**	
Level of LO	**LO (7 Dimension)**	**DLO (3 Dimensions)**	***Sub-dimension (DigiLOIS)**
Individual Level	i. Continuous Learning ii. Inquiry and Dialogue	Individual Digital Learning (IDL)	i.Continuous Digital Learning i.Inquiry and Dialogue through Digital Platforms
Team Level	i. Team Learning	Team-based digital learning (TDL)	i. Team Learning Through Digital Platforms

			ii. Digital Learning System iii. Empowerment
Organisational Level	i. Learning System v. Empowerment vi. School Relationships vii. Leadership	Organizational digital learning (ODL)	i. Digital Network System ii. Leadership that Supports Digital Learning

* Sub-dimensions = Elements that remain consistent from the seven dimensions of Marsick and Watkins (2003), extracted through the EFA procedure.

DigiLOIS is viewed as an extension of previous research (Marsick & Watkins, 2003; Yang et al., 2004; Tengku-Ariffin, 2010), transitioning from traditional LO theory into a contemporary digital learning context, not only in Malaysia but also across education systems worldwide. Furthermore, by integrating digital elements and an empirical foundation into the instrument, DigiLOIS provides a robust and relevant framework for learning in the digital era. Theoretically, DigiLOIS appears to complement the Technology Pedagogical Content Knowledge (TPACK) by linking teacher digital platforms with organizational learning culture (Schmid et al., 2024). This suggests that digital elements are crucial to enhancing the sustainability of teachers' knowledge, as it is not developed in isolation but nurtured through systemic support, leadership, and team collaboration (Chughtai et al., 2023; Hargitai & Bencsik, 2023; Luna et al., 2022; Müller & Leyer, 2023; Silins & Mulford, 2004). In terms of methodological contributions, DigiLOIS employs a rigorous two-step validation process, integrating EFA and CFA, and uses a two-sample design (EFA, n = 200; CFA, n = 373). Furthermore, the second-order model provided strong empirical support for the three levels (IDL, TDL, and ODL), as proposed in the earlier work.

The validated DigiLOIS instrument has several practical applications for various education stakeholders. For policymakers, DigiLOIS enables data-driven evaluation of schools' digital learning culture, supporting alignment with Sustainable Development Goal 4 (SDG 4) and, as in the case of Malaysia, the strategies of national digital education (Dasar Pendidikan Digital) (Senge, 1990; 1994; 1996). In addition, school leaders will be provided with evidence-based guidance to strengthen professional learning communities (PLCs), enhance digital collaboration, and promote leadership practices that support digital learning (Tengku-Ariffin, 2010; Müller & Leyer, 2023; Ahmad, 2024; Tandon, 2020; Dahanayake & Gamlath, 2013). Moreover, DigiLOIS can be used as a tool to help teachers identify individual, team, and organizational-level digital learning practices, thereby encouraging reflection on their professional growth within a digitally connected learning ecosystem. Ultimately, DigiLOIS offers researchers a standardized and validated tool for conducting comparative studies across diverse countries and contexts. DigiLOIS holds the potential to contribute to the scholarly discourse on digital transformation in education by providing a validated framework for cross-contextual evaluation and research.

The deletion of 2 items removed during the EFA procedure due to low factor loadings improved the statistical and conceptual clarity of DigiLOIS. This step reflects that digital decision-making and teacher autonomy can vary across school systems, as supported by several scholars (Awasthy & Gupta, 2012; Tandon, 2020; Dahanayake & Gamlath, 2013). Therefore, removing these items strengthens the instrument's structural validity and supports its global applicability. DigiLOIS addresses these gaps by providing a 19-item instrument that combines the conventional seven-dimensional DLOQ into three practical dimensions: IDL, TDL, and ODL. This study strengthens the instrument's theoretical rigor.

Table 5. Evolution of Learning Organization Instrument

Aspect	**DLOQ (Marsick & Watkins, 2003)**	**SLOQ (Tengku-Ariffin, 2010)**	**DigiLOIS**
Purpose	To measure the culture of LO in business and general organizations.	To adapt DLOQ for the Malaysian school context	To integrate digital elements (from SLOQ) into the LO framework for school culture
Dimensions	7 dimensions.	7 dimensions	3 dimensions
Items	43 items.	21 items (11 adapted, 8 from long DLOQ, 2 new items)	19 items (Refined from SLOQ, 2 items removed after EFA)
Validation Approach	Empirical testing through reliability and correlation analysis.	EFA (n=150) CFA(n=366) Confirmed 7 dimensions of LO	Content Validity (CVR, CVI), EFA (n=200). CFA (n=373)

Sample Context	More than 200 companies in the business/industry context and general organizations.	Teachers of Malaysian secondary schools	Teachers of Malaysian secondary schools, with larger and multi–stage sampling
Focus	General organization learning without a school context and digital elements.	LO in the school context, without digital integration	Digital learning culture in schools
Contribution	Established a foundation study of validation instrumentation in the extended version.	LO framework for school context, with 7 dimensions in the short version.	Digitalized the existing tool by simplifying it into 3 dimensions, which linked to the level of LO (Individual, team, and organizational).
Differences	Lack of education context. No EFA and CFA empirical validation	Lack of digital elements	Include digital elements with EFA and CFA validation

To explain Table 5, the evolution of DigiLOIS enhances the theoretical framework of learning organization research in three critical ways. Firstly, the DLOQ by Marsick and Watkins (2003) focused on learning in organizations. Secondly, after Yang et al. (2004) modified the extended 43-item version into a 21-item version, the SLOQ proved suitable for measuring LO in the school context. Eventually, the DigiLOIS goes further by combining digital practices, including online collaboration, sharing digital resources, and technology-based professional development. Overall, this recontextualization positions digitalization not merely as an external supplementary feature but as an intrinsic aspect of organizational learning in educational institutions.

DigiLOIS enhances the methodology by providing researchers with a psychometrically valid tool that simplifies complex ideas into a 19-item, three-precise second-order dimensions: IDL, TDL, and ODL. This is achieved through the use of CVR, EFA, and CFA for validation across different datasets. This simplicity and robustness enable academics and practitioners to assess the digital learning culture in schools with greater accuracy and clarity, thereby addressing the limitations of earlier tools that were overly complicated or did not fit the situation. This concept was supported by Ifenthaler et al. (2021), who emphasized that this contribution aligns with the digital learning culture. For example, new research on digital learning learning who has revealed differences in approaches compared to traditional physical learning, suggesting that a hybrid method has a positive influence on the teaching and learning process (Artüz & Bayraktar, 2021; Hargaitai & Bensick, 2023; Sousa & Rocha, 2019).

The DigiLOIS appears to align with Social Cognitive Theory (SCT) proposed by Bandura (1986). The SCT emphasized the interconnectedness of personal, social, and environmental support in nurturing a school's learning culture, and how this relates to the IDL, TDL, and ODL elements. The theory, defined by the ODL, represents the social environment that supports the personal elements, in which teachers collaborate within the team through TDL and, through the IDL, affect behavioral factors to support continuous learning among teachers in the school. Overall, DigiLOIS stands not only as a validated measurement instrument but also as a theoretical enhancement that digitalizes organizational learning concepts, aligns them with current educational issues, and lays the groundwork for future empirical and comparative research across educational systems worldwide.

6 CONCLUSIONS

This study validated the Digital Learning Organization Instrument for Schools (DigiLOIS), confirming a robust three-dimensional structure comprising Individual Digital Learning (IDL), Team-Based Digital Learning (TDL), and Organizational Digital Learning (ODL), containing 19 items, by integrating digital learning into the traditional LO framework. In conclusion, these findings extend the conventional LO model and align it with contemporary demands for digital transformation in education. In this article, the novelty of the research is as follows:

- Methodologically, DigiLOIS provides an empirical measurement tool that reflects the CVR, CVI, EFA, and CFA through the robust two different datasets. DigiLOIS is viewed as a digitalized refinement of existing learning organization instruments, in which complex 7-component instruments are simplified into three core dimensions: IDL, TDL, and ODL.
- This research highlights the new concept of learning culture which use the human capital within the school and utilize the digital platforms to enhance the effectiveness among teachers.

This new instrument is seen as a robust measurement tool for the Digital Learning Organization (DLO) for researchers, school leaders, and policymakers in the new digital era of the education system. Regarding limitations and future research suggestions, the focus should be on evaluating the implementation of the current policy to improve ethical practices in DLO. In addition, the prolonged digital engagement will affect work-life balance and lead to digital burnout. The concern about mental health issues related to the continuous DLO will

ruin the psychological well-being of teachers. Future research should concentrate more on digital well-being. Methodologically, a mixed-methods or qualitative study should be recommended. These methods are crucial for ensuring a more comprehensive understanding, particularly regarding teachers' perceptions, readiness, literacy, and emotional responses towards DLO. Consequently, DigiLOIS offers policymakers, school leaders, teachers, and researchers a practical and empirically validated instrument for understanding and enhancing digital learning cultures within educational institutions.

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