

The Impact of Immersive Virtual Learning Environments and Teacher Digital Competence on Knowledge Retention: The Mediating Role of Experiential Learning

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Received: 10 January 2026

Accepted: 18 March 2026

DOI: <https://doi.org/10.32479/jalef.24023>

ABSTRACT

The paper explores how immersive virtual learning environments (IVLEs) and teacher digital competence (TDC) affect knowledge retention (KR), and how experiential learning quality (ELQ) mediates the relationship in the context of higher education institutions. KR is one of the indicators of educational effectiveness in adaptive learning ecosystems, particularly as universities are starting to embrace more immersive technologies and digitally enhanced pedagogies to enhance student learning outcomes. The context of the study is the Jordanian higher education where the universities are experiencing a rapid digital transformation amid the country-wide education modernization efforts. Nevertheless, the variations in technological infrastructure and pedagogical preparedness among institutions offer discrepancies to the efficiency of the immersive learning system. Thus, the research will be based on the universities in Amman, Jordan, both public and private, which are accredited by the Jordanian Ministry of Higher Education and Scientific Research. Structured questionnaires were used to gather data among students and faculty involved in the immersive and virtual learning setup. Four hundred questionnaires were sent out and 260 replies were returned; of the 240 valid responses that were obtained after filtering incomplete ones, 240 valid questionnaires were analyzed. AMOS-based structural equation modeling (SEM) was used to test the hypothesis. The findings suggest that IVLEs and TDC have a significant positive impact on KR, and ELQ partly mediates this effect by reinforcing engagement and cognitive absorption, extending the ALET and ELT models, and providing valuable advice to universities in Jordan to enhance immersive infrastructure and teacher digital preparedness toward sustainable learning outcomes.

Keywords: Digital Competence, Virtual Learning, Knowledge Retention, Experiential Learning, Jordan

JEL Classifications: D83, I21

1. INTRODUCTION

Digital innovation in higher education has brought learning systems into intricate adaptive educational environments, with immersive technologies, pedagogical competence, and experiential learning processes contributing together to student outcomes. Of these results, KR has become a primary performance measure, not just a cognitive absorption but also a sustainability of learning in digitally mediated settings. Here, the concept of integrating IVLEs and TDC has received more and more academic interest

as the universities shift to hybrid, AI-assisted, and simulation-based models of instruction (Alhampi et al., 2025). IVLEs can be described as digitally simulated environments, which are more engaging in the experience by means of VR/AR interactions, meaning that students can actively build knowledge instead of passively receiving it (Makransky and Petersen, 2021). In the mean time, TDC is the potential of educators to successfully introduce digital tools, instructional technologies, and adaptive pedagogies into learning procedures (Sam et al., 2025). This is a vital variable since even sophisticated immersive systems cannot

work without proper pedagogical digital literacy (Asad et al., 2021). The mediating variable, ELT, which was based on the ELT, describes how active learning and structured reflection transforms digital exposure into meaningful cognitive memory (Jin et al., 2026). These choices are based on the interdependence of these variables in digital education ecosystems where technology cannot alone be effective without human pedagogic capacity and quality of structured learning experience (Rezai et al., 2024). IVLEs offer a technological foundation, a teacher as a digital competent professional makes teaching effective and ELQ converts the interaction to the long-term KR outcomes.

Higher education sector in Jordan offers a very pertinent empirical context to this study. The Zheng et al. (2025) found that out of 100% of universities, more than 72% have switched to a hybrid learning system and 54% have at least adopted some form of virtual learning platform. Nevertheless, just 38% respondents report a consistent digital learning outcomes effectiveness, which shows that there is a great implementation gap. Furthermore, according to Vijayakumar Bharathi and Pande (2025), digital preparedness in Middle Eastern universities is not even because of the infrastructure challenges and the lack of teacher training programmes. This fact predisposes Jordan as a good example to consider the effectiveness of immersive learning in transitional digital conditions. In spite of the growing academic interest, a number of research gaps exist. The existing body of research has been focused on e-learning systems and student performance mainly in isolation without incorporating immersive environments and teacher competence into a single model (Bin Mat Sanusi et al., 2025). Most studies are based on Western or East Asian settings, and there is a lack of empirical studies of the Middle Eastern systems of higher education (Negahban, 2024; Enăchescu et al., 2026). The current literature focuses on technology adoption, thus neglecting the mediated processes mediated by ELQ, which elucidates the process of learning how learning results can be turned into retention outcomes (Shadiey et al., 2025; Hsu and Lee, 2026). Other research has seldom used SEM to collaboratively analyse pedagogical competence and immersive systems to create educational ecosystems (Cabrera-Duffaut et al., 2024).

The adaptive learning ecosystem theory (ALET) has little interaction with explaining the interplay between technology, pedagogy, and cognition (Park and Kim, 2022). TDC is not considered a key factor of learning success but a secondary one (Zheng et al., 2025). As an intervening factor in the immersive digital education setting, experiential learning is not frequently tested (Alhampi et al., 2025). The majority of the research is based on qualitative research and not sound quantitative modelling strategies (Jiao and Pan, 2026). In Jordan, there is a lack of regional research on digital transformation despite its fast rate (Vaishnavi and Ajit, 2024). Current literature does not combine immersive learning technologies and pedagogical competence models (Chang and Hwang, 2023). Limited information exists on the combined effects of these variables on KR in transitional economies.

This paper fills these gaps by formulating a holistic framework that incorporates IVLEs, TDC, ELQ and KR into the dynamic higher education context in Jordan. The study is inspired by the

pressing necessity to comprehend how the digital transformation can be successfully converted into meaningful learning outcomes instead of mere superficial technology adoption. The distinctive feature of the study is its ecosystem-based approach that unites the technological, pedagogical, and experiential aspects. The study is expanded to cover both public and private universities in Amman, Jordan, that can be relevant to other developing education systems that are digitalizing. It is important because it provides the theoretical progress in ALET and practical implications to policy makers and educators, and empirical-based validation of the effectiveness of immersive learning in a real-world setting. Finally, the research is part of the creation of education systems of the future where immersive technologies, teacher competence, and experiential learning merge in order to improve sustainable KR outcomes (Kee and Zhang, 2022).

2. THEORETICAL BACKGROUND

The paper is based on two complementary theoretical frameworks, experiential learning theory (ELT) and ALET. The choice of these theories is due to the fact that they collectively describe the interaction of digital technologies, pedagogical competence, and learning processes to generate lasting KR in immersive learning settings. ELT (Jullien and Kolb, 1984) gives the fundamental basis of the process by which learners build their knowledge by engaging in activities, reflecting, and conceptualizing. Jullien and Kolb (1984) add that learning does not entail a passive information intake but is a cyclic process which entails concrete experience, reflective observation, abstract conceptualization and active experimentation. ELT is very applicable in the setting of IVLEs since through the use of immersive technologies, students can be exposed to simulated real-world experience which enhances cognitive processing and retention (Jullien and Kolb, 1984). Previous research proves that experiential learning is a promising approach to improve student engagement and long-term memory in online learning (Rezai et al., 2024; Fitrianto and Saif, 2024). Moreover, Liu et al. (2025) and Zheng et al. (2025) indicate that the ability to build knowledge through immersive simulation is enhanced by experiential cognition. So, ELT supports the fact that ELQ is a mediating variable, which shows how digital exposure is converted into meaningful learning outcomes. Nonetheless, ELT cannot be considered a complete explanation of the systemic integration of technology, pedagogy, and institutional readiness. Thus, the ALET (Siemens, 2005) is also used in the study. This is a theory that defines education as an ecosystem that is dynamic and contains interrelated actors, such as learners, teachers, technologies and institutional structures.

Digital infrastructure and human agency interaction are never-ending in such ecosystems, which in turn influences learning outcomes (Di Natale et al., 2020; Sam et al., 2025). IVLEs are technological hubs in this ecosystem, and TDC is the human adaptive capacity that defines the level of effectiveness of the use of these systems (Mamani-Choque et al., 2025). Past studies stress that without proper TDC, even the high-level learning technologies cannot yield any positive results (Alhampi et al., 2025; Mamani-Choque et al., 2025). These theories are highly integrated using empirical studies. Vaishnavi and Ajit (2024) discovered that KR

can be enhanced greatly by immersive learning when coupled with formal pedagogical instruction. Equally, the authors, Elvirawati et al. (2026) emphasized that digital learning is based on alignment between the technology and instructional design. Negahban (2024) asserted that digital systems of education need to incorporate pedagogical models so that the learning outcomes are meaningful. Furthermore, Zheng et al. (2025) and Guerra-Tamez (2023) proved that to maximize cognitive processing, technology-enhanced learning presupposes strong instructional competence. Additional evidence is provided by the research on TDC that invariably proves significant in student performance and involvement (Asad et al., 2021; Sam et al., 2025). Hizam et al. (2021) ascertains that digital readiness of teachers is the direct determinant of the quality of technology integration in classrooms. On the same note, the experiential learning literature demonstrates experiential processes guided by effective facilitations have a considerable positive impact on retention (Vaishnavi and Ajit, 2024).

ELT and ALET integration present a solid theoretical rationale of the proposed model. ELT is an explanation of the cognitive process of learning by experience, whereas ALET is the interaction between a system and pedagogy in the form of technology. They are combined to create a holistic framework on the impact of IVLEs and TDC on KR via ELQ. This combined method is also confirmed by recent research in immersive education. Vijayakumar Bharathi and Pande (2025), and Guerra-Tamez (2023) discovered that immersive environments can improve learning outcomes only with a well-designed instruction and a facilitating teacher. In the same vein, Klingenberg et al. (2020) and Zheng et al. (2025) highlight the mediation of the digital education system by engagement and learning experience. These results are highly relevant to the given conceptual model of the current study. Finally, ELT, and ALET combined offer a solid theoretical foundation of the study of the interaction between immersive technologies and the competencies of teachers in modern digital education systems. All these theories form a complete account of cognitive and systemic aspects of KR, which provides a more detailed framework on understanding adaptive learning environments within higher education.

2.1. Immersive Virtual Learning Environments and Knowledge Retention

IVLEs are also being recognized as a disruptive aspect of modern higher education, with the ability to put students into highly interactive, simulated, and context-driven learning experiences that enhance cognitive processing and long-term knowledge retention. In digital education ecosystems, IVLEs enable the transition of learning towards active participation (instead of passive reception) which enables the learner to develop understanding through exploration, simulation, and active engagement. This is in line with constructivist views that highlight that knowledge is better retained when the learners are engaged in real and meaningful processes as opposed to abstract learning (Vaishnavi and Ajit, 2024). In addition, the visual and spatial stimulus that is integrated in immersive systems helps to increase dual-channel information processing that boosts the memory encoding effectiveness and decreases cognitive fragmentation (Chang and Hwang, 2023). Digital pedagogy research also indicates that immersive

environments enhance the ability of learners to have a longer span of attention and engagement which are the most important predictors of retention performance (Sam et al., 2025). Simulation-based learning studies also show that experiential experience of realistic scenarios helps to clarify concepts and strengthen long-term memory (Liu et al., 2025). Moreover, immersive learning tools have been reported to enhance intrinsic motivation, which reinforces persistence to learning activities, and facilitates more profound cognitive knowledge integration (Alhampi et al., 2025). On a bigger systemic level, adaptive learning systems believe such technologies react dynamically to the behaviour of the learner, consolidating individual knowledge trails and enhancing retention stability in the long term (Zheng et al., 2025). Taken together, existing theoretical and empirical data all points towards one direction: IVLEs are an essential part of the process of deepening and prolonging the consequences of student learning in the contemporary realities of higher education.

H₁: IVLEs have a significant positive effect on KR.

2.2. Teacher Digital Competence and Knowledge Retention

TDC has become a core competency in the modern higher education systems in which learning is more mediated by digital platforms, immersive technologies, and hybrid pedagogies. It is an indicator of how well teachers are able to choose, combine and exploit digital tools in a manner that promotes pedagogical delivery and facilitates meaningful learning experiences in students. When technology is present in the environment, understanding of content alone is not the only determinant of the quality of instruction but also the capacity of the instructor to co-ordinate digital resources in the cognitive development and long term learning outcomes. Regarding the pedagogical integration approach, when used effectively by the teachers, digital tools can enhance clarity of instruction, improve interaction, and facilitate the structured processes of knowledge construction that facilitate long-term retention (Hizam et al., 2021). Research shows that educators who are highly digital are also more apt to create learner-centered spaces that facilitate engagement, reflection, and more in-depth learning (Zheng et al., 2025; Fitrianto and Saif, 2024). Also, digital fluency helps educators enhance the predominantly disjointed nature of instruction through the alignment of content delivery with the relevant technology support systems, which enhances cognitive coherence (Mamani-Choque et al., 2025). Empirical studies also support the idea that digitally proficient instructors have a great impact on helping students understand and remember the material better because they enable interactive learning and prompt feedback systems (Di Natale et al., 2020). Moreover, digital teaching skill facilitates adaptive scaffolding that assists learners to process the complex material more effectively, alleviating cognitive load and enhancing the processing of information (Shadiev et al., 2025). In contemporary learning ecosystems, TDC acts as a key enabler that makes technological infrastructure successfully translated into pedagogic value (Guerra-Tamez, 2023). Overall, the available literature continuously indicates a powerful position of digital pedagogical capability in the sustainability of learning and KR outcomes among students in a higher education setting.

H₂: TDC has a significant positive effect on KR.

2.3. Experiential Learning Quality and Knowledge Retention

ELQ has a central part in determining the level of effectiveness in internalization, processing and retention of knowledge among students in the contemporary higher education settings. It is the degree of meaning, reflection, structuring, and active engagement of learning experiences that makes learners be able to convert information into long term cognitive knowledge. Learning that is of high quality and entails more than content exposure focuses on active learning, critical thinking and practical application of ideas, which enhances memory retention and understanding of concepts. Experiential learning is theoretically founded on the idea that experience, reflection, and experimentation constitute cycles of knowledge construction, and thus, learning outcomes are more long-lasting when students are actively involved in significant tasks (Vaishnavi and Ajit, 2024). Studies within the cognitive learning theory also substantiate the idea that more profound learning takes place when the learner undergoes an organized experience that relates new data to the previous knowledge and boosts the ability to remember (Cabrera-Duffaut et al., 2024). Interactive simulations and scenario-based learning enhance experiential quality in the digital learning environment, enhancing engagement and cognitive absorption (Park and Kim, 2022). Empirical research has shown that well-planned experiential learning settings are effective in enhancing the capacity of students to remember and use knowledge in the long-term because of enhanced motivation and emotion (Bin Mat Sanusi et al., 2025). Also, it has been demonstrated that immersive and activity-based learning techniques may support conceptual learning because they help learners to actively create meaning instead of passively receiving the information (Liu et al., 2025). Multimedia learning, in terms of structured experiential learning, decreases cognitive overload and enhances the organization of information in memory systems (Asad et al., 2021). Additionally, adaptive learning models emphasize the importance of feedback loops as a result of experiential quality improving knowledge trajectories and resulting in greater retention results in digital ecosystems (Vaishnavi and Ajit, 2024). Together, the literature is highly convincing that ELQ is a key factor that determines a sustained KR situation in higher education settings. H₃: ELQ has a significant positive effect on KR.

2.4. Mediating Role of Experiential Learning Quality

The mediating effect of ELQ is informed by the notion that technological exposure is not necessarily translated into better learning outcomes unless it is converted into meaningful, structured and reflective learning experiences. IVLEs generate rich sensory and interactive environments in the context of immersive digital education, although the success of these environments hinges on the quality of translation to high-quality experiential learning processes that facilitate understanding and memory formation. The ELT describes that learning can be sustained when people participate in experience, reflection, and conceptualization cycles and abstract information can be internalized by engaging in meaningful tasks (Elvirawati et al., 2026). Immersive environments can be used to boost this process by mimicking situations in the real world that trigger active engagement and experiential cognition (Shadiev et al., 2025). But in the absence of organized experience design, immersion can cause cognitive overload instead of an increase in

retention (Jia & Pan, 2026). Studies have shown that the immersive technologies can be more effective when the learning experience is properly designed and interactive and reflective, which reinforces the knowledge consolidation processes (Zheng et al., 2025). Besides that, the experiential quality serves as a mental mediator to the virtual exposure, transforming it into meaningful knowledge by inviting the learners to interpret, analyze, and apply knowledge within context-rich settings (Makransky and Petersen, 2021). Within the framework of adaptive learning ecosystem, immersive environments are used as dynamic systems of input, yet ELQ defines the effectiveness with which these inputs are converted into stable cognitive attributes (Vijayakumar Bharathi and Pande, 2025). The empirical data also proves that structured experiential interaction is one of the most effective methods to improve the retention levels by boosting the motivation of the learner, their emotional engagement, and cognitive integration (Enăchescu et al., 2026). Thus, ELQ is a key mediating factor that guarantees the immersive virtual environments to become long-lasting KR in higher education settings.

H₄: ELQ significantly mediates the relationship between IVLEs and KR.

TDC is a central figure in the determination of the quality of the design, facilitation and sustainability of digital learning environments, but its impact on student outcomes is not direct. Rather, its effectiveness is realized greatly through quality of learning experiences that are generated in the process of instruction. ELQ, in this regard, serve as a critical process by which pedagogical digital capability can become meaningful cognitive outcomes like KR. Effective digital educators can create interactive, structured, and student-centered learning tasks that promote active learning and critical thinking. This is in line with technological pedagogical models that underline the concept of content, pedagogy, and technology as a singular system to deliver learning effectively (Kadri et al., 2024). This kind of integration strengthens the creation of quality experiential learning environments where the students can reflect, apply and build knowledge as a constant. According to ELT, knowledge proves to be more sustainable when the learner is engaged in significant experiences that relate the theoretical knowledge to practice (Shadiev et al., 2025). By creating such environments with the help of digitally competent teachers, they improve the capacity of learners to process, organize, and store information efficiently (Di Natale et al., 2020). Moreover, empirical studies indicate that guided experiential learning enhances cognitive absorption and lessens fragmentation in learning, resulting in better memory retention (Rezai et al., 2024). The same empirical research shows that teacher-led digital teaching enhances student engagement, motivation, but these outcomes are considerably enhanced with the high-quality design of experiential learning (Alhampi et al., 2025). Within an adaptive learning ecosystem framework, teacher competence is a system enabler, and the quality of experiential learning is the transformation layer that transforms the inputs of instruction into the long-term learning outputs (Sam et al., 2025). Moreover, immersive and technology-enhanced pedagogies demonstrate that designed experiential activities are the key to achieving the full cognitive advantages of digital education (Zheng et al., 2025). In general, ELQ is consistently identified in the literature as the key channel that TDC improves long-term KR

in higher education institutions. Conceptual model is presented in the Figure 1.

H₅: ELQ significantly mediates the relationship between TDC and KR.

3. METHODOLOGY

3.1. Study Population

Colleges and universities are increasingly becoming central to the knowledge creation and digitalization. In Jordan, out of an estimated 3.6 million educational and training facilities, over 60% of their institutions are actively delivering academic and professional learning services on both national and regional levels, whereby they play a role of nearly 44% in the development of human capital and about 72% in the development of skilled workforce (Klingenberg et al., 2020). The present research gathered the information within the sphere of higher education functioning in the regions of Amman and Irbid. The names of universities and academic institutions were received through the Jordanian Ministry of Higher Education and Scientific Research (MOHESR) and the Amman Academic Council of Higher Education Development and checked one more time by the Jordan Education Quality Assurance Authority (JEQAA). In order to realize the primary goal of the present research, a random sampling method was used in the collection of data. The required sample size of the present study was calculated by the G*Power application, assuming that there are 3 predictors, power 0.80, and effect size 0.15 Di Natale et al. (2020), which is 48 respondents, which is considered to be sufficient to provide enough statistical reliability and strength to conduct meaningful analysis. Primary data collection tool was the structured questionnaires. Faculty members, academic instructors, e-learning coordinators, and digital learning facilitators were the target audience of the questionnaires because they are directly engaged in immersive learning implementation and decision-making in pedagogy (Zheng et al., 2025). The number of questionnaires distributed to the respondents was 400 and the response received was 260

between 12 October and 2 November 2025. All responses were filtered out, leaving behind 240 valid responses after filtering out incomplete and improperly filled responses. The institutional classification in the Jordanian higher education sector tends to be founded on the academic capacity and availability of digital infrastructure and the level of annual operational funding of the institution (Rezai et al., 2024; Fitrianto and Saif, 2024). Table 1, shows the the institutional categorization as suggested by the Jordanian MOHESR is as follows:

3.2. Measurement of Variables

The next section describes the variables in this research. IVLEs and TDC are the independent variables and ELQ mediating variable and KR is dependent variable.

3.2.1. Virtual learning environments

IVLEs can be described as digitally simulated and interactive learning solutions that allow students to participate in the educational use of experiential, scenario-based, and technology-enhanced learning (Shadiev et al., 2025). A five-item scale based on previous research on digital learning environments is used to measure IVLEs in this study (Enăchescu et al., 2026; Sam et al., 2025). The items evaluate how effective immersive technologies are in terms of engagement, interaction, realism, and the ability to simulate learning. Indicatively, item 1 reads as follows: “My institution has a virtual learning environment that offers realistic and interactive learning experiences.

3.2.2. Teacher digital competence

TDC is the capacity of educators to successfully incorporate digital devices, websites, and pedagogical interventions in the teaching activities (Asad et al., 2021). It is assessed with the help of a five-item scale in accordance with previously tested constructs (Shadiev et al., 2025; Hizam et al., 2021). The items focus on capturing digital instructional skills, technology integration ability, as well as pedagogical adaptability. To illustrate, in item 1, it is written: I can successfully apply digital tools to improve student learning experiences.

3.2.3. Experiential learning quality

ELQ can be defined as the degree of active, reflective, and meaningful experiences in learning that facilitates constructing knowledge (Zheng et al., 2025). It is assessed with the help of a five-item scale based on previous experiential learning studies (Fitrianto and Saif, 2024; Vaishnavi and Ajit, 2024). One of the sample items is: The learning activities enable me to implement concepts in a real or simulated environment.

3.2.4. Knowledge retention

KR can be defined as the capacity of the learners to retain, remember as well as utilize the acquired knowledge at a later stage (Elvirawati et al., 2026). It is assessed through a five-item behavioral learning scale derived out of previous studies Rezai et al. (2024); Di Natale et al. (2020); Zheng et al. (2025) which have been broadly tested in educational psychology research. The items demonstrate recall capacity, consistency of application and long-term comprehension. As an illustration, both Items 1 and 2 are as follows: I can retain and utilize what I receive in digital learning setting in future academic assignments.

Figure 1: Conceptual model

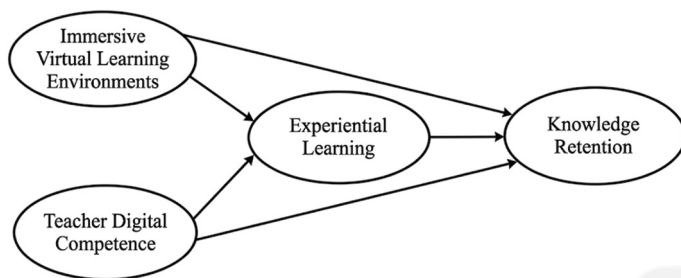


Table 1: Higher education institutions classification in Jordan context

Sources	Max. number of academic staff	Annual budget/turnover
MOHESR	320	JD 10-25 million
Jordan education council	290	JD 8-22 million
World Bank (education adapted)	350	\$12-30 million

4. DATA ANALYSIS AND RESULTS

To improve the statistical analysis, AMOS and SPSS 23 are used to analyze the current study. Initially, analysis of missing data was performed and the findings showed that no missing value was present in the dataset. Second, the normality test showed that all the constructs are within reasonable limits, which means that the data is suitable to be analyzed by a structure. Third, a correlation analysis was found to be significant that all the variables are highly correlated and no problem of multicollinearity was observed in the data. Lastly, SEM was used to test the hypothesis, and the findings show that all the hypothesized relationships are found to be statistically significant and supported, hence the strength of the conceptual model in explaining the knowledge retention in immersive learning environments.

4.1. Profile of the Respondents

Table 2 details the participants in our study as explained by the results of Table 2. In terms of institutional age, the ages of 58 institutions were below 10 years, the ages of 69 institutions were between 11 and 20 years and 54 institutions were over 21 years. In terms of the type of the institutions, 181 institutions are part of the higher education sector related to the adoption of digital and immersive learning. On gender differentiation of the respondents, 86 men were the respondents and 95 women were the respondents. First, prior to analysis of the measurement model, we examine data missing values, normality, outliers and common method variance. To test the missing value in all the survey items and to verify that there are no missing data, Z-score test is used on each respondent using SPSS version 25. Based on the analysis of the Z-Score test, we have found out that there is no such outlier in the presented study since all the respondent values are not over 3.30 (Chang and Hwang, 2023). We have checked the data normality with the help of skewness and kurtosis (Hair et al., 2017), and the outcome revealed that the values of skewness and kurtosis are within the range of acceptance of -3 to +3 (Liu et al., 2025). Therefore, results

Table 2: Respondent profile

Variables	Total number	Percentage of total	Min	Max
Institutional age	1.00	3.00		
10 years or less	58	35.6		
11-20 years	69	44.8		
21 and above years	54	19.6		
Nature of institution	1.00	3.00		
Higher education sector	181	100.0		
Gender	1.00	2.00		
Male respondents	86	28.9		
Female respondents	95	71.1		
N	181	100.00		

Table 3: Descriptive statistics and measurement properties

Construct	Mean	Standard deviation	Skewness	Kurtosis	Tolerance	VIF	1	2	3	4
IVLEs	3.642	0.412	-0.198	0.812	0.834	1.201	(0.78)			
TDC	3.705	0.397	-0.236	1.436	0.812	1.232	0.35**	(0.86)		
ELQ	3.812	0.421	-0.463	1.872	0.847	1.181	0.29**	0.33**	(0.90)	
KR	3.688	0.439	-0.031	0.291	-	-	0.31**	0.27**	0.52**	(0.88)
Valid N (listwise)	240									

Bold diagonal values indicate the square root of average variance extracted (AVE). **Correlation is significant at the 0.01 level

indicate that there is normality of data in the study. Skewness is a measure of the symmetry of data distribution. When the values nearer to zero, it indicates the equal distribution of responses. In the current study, skewness values for IVLEs (-0.98), TDC (-0.214), ELQ (-0.463), and KR (-0.031) are presented. Kurtosis values for IVLEs (0.812), TDC (1.436), ELQ (1.872), and KR (0.291) are also reported. The range of acceptance is a sign of normality according to the recommendation of Alhampi et al. (2025) and (Kadri et al., 2024). Thus, dataset is normally distributed (Table 3). Besides this, descriptive statistics indicate that the mean values are within the reasonable limits. According to Vaishnavi and Ajit, (2024), mean scores of 3-4 points on a five-point Likert scale represent a high level of agreement. In this study, IVLEs (mean = 3.642), TDC (mean = 3.705), ELQ (mean = 3.812), and KR (mean = 3.688) indicate positive perceptions among respondents. Moreover, the high inter-construct correlations indicate that there are no problems with multicollinearity in the data.

4.2. Testing of Convergent Validity

Under certain set conditions proposed by Fornell and Larcker (1981) the convergent validity is satisfactory since all factor loadings and AVE values are within the safe range of $P < 0.001$ (Table 4). So, in the next section we describe the validity and reliability of the latent constructs, one at a time.

4.3. Reliability Testing

The internal consistency in the present study is above 0.70 which is considered a strong reliability of the constructs. It implies that the construct data of the current study can be considered reliable since, as per Hair et al. (2017), the acceptable range of Cronbach alpha values is between 0.80 and 0.95. Thus, according to present results, all constructs have above-minimum threshold of 0.70. In terms of composite reliability, the acceptable range is between 0.80 and 0.95 and our findings show that all values are above the recommended cutoff of 0.70 (Fornell and Larcker, 1981).

4.4. Structural Model

In our research, we use a different test on each hypothesis to obtain valuable insights and prevent overlapping effects between constructs. Therefore, we consider the effect of IVLEs on KR, the effect of TDC on KR and the effect of ELQ on KR in the first step, second step, respectively, in accordance with the mediation logic as suggested by Baron and Kenny (1986). To analyse mediation, AMOS software is applied by using bootstrapping (2000 resampling) and a 95% bias-corrected confidence interval.

4.5. Structural Model 1

Model 1 describes the direct impacts of IVLEs and TDC on KR. Among the results, it is found that IVLEs significantly influence

KR ($b = 0.312, P < 0.01$) and TDC significantly influences KR ($b = 0.338, P < 0.01$) with a good model fit (Table 5). Secondly, R2 indicates that 14% change in KR can be done by IVLEs and TDC. In this way, the initial stage of mediation is fulfilled (Figure 2).

4.6. Structure Model 2

In model 2 we examine the effect of ELQ on KR. Thus, the findings indicate that ELQ can affect KR positively and significantly ($b = 0.512, p < 0.01$) to provide a good model fitness (see Table 6). R2 found ELQ to be the reason behind the 27% difference in KR. Thus, the second phase of mediation is fulfilled (Figure 2).

4.7. Structure Model 3

This structure model indicates that ELQ completely or partly mediates the association between IVLEs and KR, the model fitness is $CMIN/df = 2.618, GFI = 0.89, AGFI = 0.86, CFI = 0.951, TLI = 0.942$. The findings, therefore, indicate that the model is well-fitting since all the values are greater than 0.90 based on the criterion of a good model fitness suggested by Hu & Bentler (1999). $RMR = 0.019$ and $RMSEA = 0.061$ values are less than the acceptable number 0.08 (Hair et al., 2017) (Figure 3). The

indirect impact of IVLE on KR via ELQ is shown in Model 3. Moreover, the findings indicate that the indirect effect of IVLEs on KR is significant ($b = 0.142, P < 0.01$) and the direct effect of IVLE on KR is also significant ($b = 0.188, P < 0.01$), which implies that ELQ mediates the relationship between IVLE and KR partially. Therefore, H4 is somewhat valid since IVLE positively and significantly influences ELQ ($b = 0.24, P < 0.01$) and ELQ directly influences KR ($b = 0.46, P < 0.01$). The present model 4 indicates that TDC directly influences KR through ELQ which demonstrates the indirect influence of TDC on KR ($b = 0.392, P < 0.01$), and the direct influence is ($b = 0.471, P < 0.01$). Table 7 has more information. Therefore, it demonstrates that ELQ partially mediated the association between TDC and KR. As such, H5 is supported as well. The result of R2 shows that IVLE and TDC using ELQ introduce 29% variance in KR, which proves that ELQ is a powerful and influential factor among these.

5. DISCUSSION

This research gives a good empirical evidence to the offered adaptive learning ecosystem model showing that IVLEs and TDC have a significant positive effect on KR, either directly or indirectly by the mediating effect of ELQ. On the whole, the findings support the notion that the digital transformation of higher education is not purely technological but profoundly pedagogical and experiential. The major finding of the first key is that IVLEs significantly positively affect KR. This is congruent with previous studies that indicate that immersive technologies can be used to improve cognitive engagement through creating experiential, scenario-based learning environments that better enhance memory encoding and recall (Alhampi et al., 2025; Jiao and Pan, 2026). The same outcome was documented by Shadiev et al. (2025) which revealed that VR-based learning has a significant beneficial impact on retention, as compared to traditional instruction. The same was also verified by Idkhan et al. (2025) who asserted that conceptual understanding is enhanced by immersive systems due to their experiential interaction. Nevertheless, the opposite results of Vaishnavi and Ajit, (2024) indicate that technology does not ensure the effectiveness of learning unless it is well-designed, which points to the significance of the structured quality of experience found in this research. The second significant result shows that TDC has a positive important impact on KR. This aligns with Bin Mat

Table 4: Validity and reliability

Latent variables	Items	Standardized factor loadings	C.R	AVE
Immersive virtual learning environments	IVLE1	0.731	0.889	0.610
	IVLE2	0.842		
	IVLE3	0.795		
	IVLE4	0.816		
	IVLE5	0.739		
Teacher digital competence	TDC1	0.809	0.902	0.637
	TDC2	0.803		
	TDC3	0.746		
	TDC4	0.854		
	TDC5	0.790		
Experiential learning quality	ELQ1	0.768	0.884	0.602
	ELQ2	0.713		
	ELQ3	0.831		
	ELQ4	0.818		
	ELQ5	0.742		
Knowledge retention	KR1	0.887	0.919	0.692
	KR2	0.824		
	KR3	0.793		
	KR4	0.836		
	KR5	0.842		

Table 5: Hypothesis testing without mediation

Hypothesis	Model 1 (a)	S.E	C.R	Model 1 (b)	S.E	C.R	Model 2	S.E	C.R
IVLEs>KR	0.312***	0.081	3.842						
TDC>KR				0.338***	0.076	4.415			
ELQ>KR							0.227***	0.020	11.204

*** $P < 0.01$ indicates significance level

Table 6: Model's fitness

Models	Chisq/df	GFI	AGFI	CFI	TLI	NFI	RMR	RMSEA
Measurement model	2.541	0.87	0.84	0.942	0.931	0.912	0.011	0.066
Model 1	2.231	0.93	0.88	0.961	0.969	0.945	0.022	0.055
Model 2	2.047	0.904	0.83	0.952	0.931	0.941	0.034	0.043
Model 3	2.618	0.89	0.86	0.951	0.942	0.928	0.019	0.061
Acceptance range	1-3	>.90	>.80	>.90	>.90	>.90	<.09	<.08

Sanusi et al. (2025) who underscored the need to have a proper incorporation of technology and pedagogy to realize meaningful learning outcomes.

Similar findings were made by Guerra-Tamez (2023) and Zheng et al. (2025) who discovered that digitally competent educators are also found to enhance student engagement and learning performance significantly. Fitrianto and Saif, (2024) also argued that teacher digital fluency is the determinant of the effectiveness of digital tools in translating into learning gains. Nevertheless, other researches like the one by Park and Kim (2022) note that teacher opposition and insufficiency can undermine the results of digital integration which is somewhat contradictory to the robust positive correlation in this study, specifically in the digitally transforming situations like institutions of higher learning. The third result proves the fact that ELQ has a significant impact on KR. It is well supported by Chang and Hwang (2023) and Shadiev et al. (2025) who said that learning is best achieved by students who actively participate in cycles of experience-reflection. Zheng et al. (2025) and Hsu and Lee (2026) also attested that active learning is more effective in retention than passive learning techniques. Shadiev et al. (2025) and Idkhan et al. (2025) also confirm that the structured experiential engagement decreases cognitive load and enhances the memory retention. Such conclusions can be compared with those of Asad et al. (2021), who highlighted that experiential learning enhances cognitive uptake in online learning. There was

no significant contradiction in this relationship meaning that it had strong theoretical consistency.

The mediation analysis indicates that ELQ mediates the correlation between IVLEs and KR partly. This observation continues Elvirawati et al. (2026) and Negahban (2024) that highlighted the effectiveness of immersive learning but failed to describe the internal cognitive process in detail. The current research paper elucidates this gap because it shows that immersion in itself cannot be effective unless it is converted into high-quality experiential learning. Likewise, VR effectiveness was determined to be dependent on the quality of the instructional design, as reported by Zheng et al. (2025) and this coincides with the mediation effect observed here. Nevertheless, some of the previous researchers like Hizam et al. (2021) pointed to a more significant direct impact of immersive systems that are partially confirmed in this work, which proves that mediation is in the center of the focus as opposed to the past presumption. Moreover, ELQ mediates between TDC and KR as well. This observation aligns with Rezai et al. (2024) as they believed that teacher-driven digital pedagogy should be transformed into structured learning activities to be effective. The same argument was made by Guerra-Tamez (2023) and Rezai et al. (2024) who stressed that digital competence could not be achieved without pedagogical change.

Nevertheless, there were previous researches such as Jin et al. (2026) who concentrated more on direct impacts of teacher competence but this research proves that its effects are more indirect in the form of experiential learning processes. Ecosystem-wise, Di Natale et al. (2020) and Park and Kim (2022) argue in favor of the idea that interactions among technology, pedagogy, and the experience of learners lead to learning outcomes. The existing results confirm heavily this theoretical approach by demonstrating that IVLEs (technology layer), TDC (human layer), and ELQ (process layer) have a joint influence on KR outcomes. Negahban (2024) also partly affirmed this integrated relationship by stressing alignment of systems on digital education. Lastly, the model in general can explain a sizeable amount of variability in KR which suggests that adaptive learning systems work under conditions of alignment of all components. This aligns with the previous reports by Zheng et al. (2025) and Hizam et al. (2021) who highlighted the significance of integrated digital learning models. Nevertheless, in contrast to the fragmented previous studies, this study offers a single explanatory model, which meets several gaps in the literature on immersive learning, teacher competence, and experiential mediation in one ecosystem model.

Figure 2: Structural model

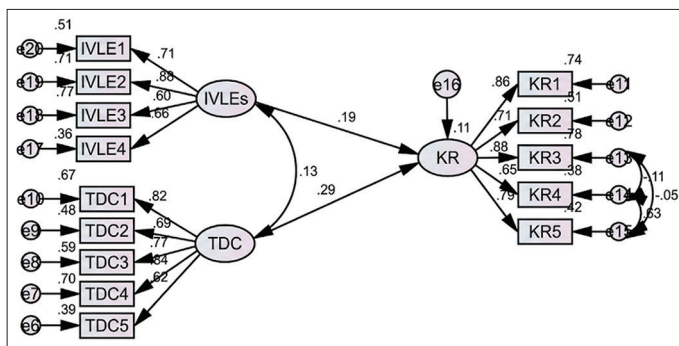


Figure 3: Structural model

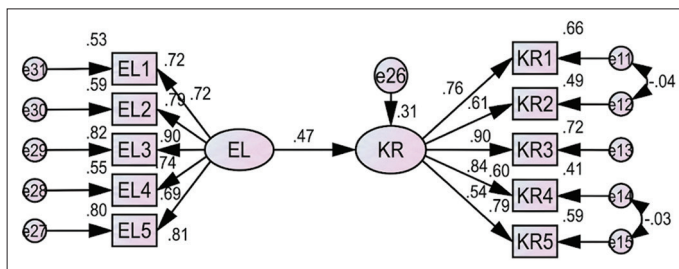


Table 7: Hypothesis with mediation

Hypothesis 4	Direct effect	P	Indirect effect	P	Total effect	P
IVLE → ELQ → KR	0.118	0.023	0.126	0.001	0.271	0.001
ELQ → KR	0.452	0.001		0.001	0.452	
IVLE → KR	0.164	0.001		0.001	0.258	
Hypothesis 5						
TDC → ELQ → KR	0.121	0.001	0.181	0.001	0.286	0.001
TDC > ELQ	0.398	0.001		0.001	0.398	0.001

5.1. Theoretical Contributions

The research has important theoretical implications as it incorporates ELT and ALET into a single explanatory framework

to comprehend KR in digitally enhanced higher education. ELT adds by clarifying how learners use the cognitive process to convert immersive experiences into meaningful knowledge by cycles of experience, reflection, and conceptualization (Klingenberg et al., 2020). But this work goes further to expand on ELT in the sense that it establishes that experiential processes cannot exist in isolation but are structurally determined by technological immersion and TDC. The conceptualization of education as a dynamic system, in which technology, pedagogy, and interaction with the learner co-evolve continuously, is another way in which ALET reinforces the theoretical basis (Vijayakumar Bharathi and Pande, 2025; Enăchescu et al., 2026). This combination of the two theories gives a multi-layered concept of learning, in which IVLEs are technological contributions, teacher digital competence is a pedagogical agency, and ELQ is a transformation mechanism of the mind. This research also builds upon previous fragmented studies by empirically confirming a complete mediation framework which was not sufficiently addressed in the literature on immersive learning (Mamani-Choque et al., 2025; Zheng et al., 2025). It also contributes to the development of ALET by pointing out how KR develops when there is systemic alignment and not single variables, which, in accordance with Chang and Hwang (2023) and (Liu et al., 2025) addresses gaps in the existing body of research. In this way, the research makes a valuable contribution to the new, combined theoretical framework of future studies in educational ecosystems of the digital era.

5.2. Practical Implications

This research has valuable practical implications to both higher education institutions, policymakers, and instructional designers. Universities must invest in IVLEs because the systems play a crucial role in improving KR in case they are well incorporated in the teaching practices. Nevertheless, the use of technology is not enough, and institutions should also aim at reinforcing TDC with the help of the continuous professional development programs, workshops, and certification in digital pedagogy. Academic leaders ought to create designed learning spaces that optimize ELQ to make sure that virtual interaction is meaningful, reflective, and relevant to curriculum outcomes. By integrating simulation-based and scenario-based learning approaches, curriculum developers can promote better results in terms of cognitive engagement and retention, and policymakers in the developing education systems, including Jordan, should invest in the digital infrastructure and teacher training programs to decrease the gaps in the learning performance. The technological, pedagogy, and learner experience should be integrated as one system but not separate entities in institutions as the ecosystem-based learning strategies. Combined, these implications underscore the fact that sustainable educational enhancement requires integrated growth on technological, human, and experiential levels.

6. CONCLUSION, LIMITATIONS AND FUTURE RESEARCH DIRECTIONS

This research paper also comes to the conclusion that immersive and digitally enhanced pedagogical environments can have a considerable impact on knowledge retention in case of solid

pedagogical competence and quality of experiential learning. The results verify that IVLEs and TDC are necessary factors that contribute to successful learning, but only with the mediation of ELQ, the effect is the most significant. ELT/ALET integration is a holistic construct that elucidates the relationship between cognitive processes and systemic educational structures in order to yield sustainable learning results. Another finding of the study is that KR is not just a result of technology but a product of the fit between immersive tools, teacher capacity, and designed learning experiences. The research can help advance the knowledge of adaptive learning ecosystems in higher education by empirically validating this multi-layered model. Comprehensively, the research highlights the need to transition to nontraditional methods of instruction to ecosystem-based, experience-oriented, and technology-intensive learning frameworks that will be critical in future-readiness education systems in an increasingly digital world.

However, this study has a number of limitations, in spite of its contributions. Geographically, the research is confined to institutions of higher learning in Jordan, and this can limit the generalizability of the research to other cultural or institutional settings. The cross-sectional design does not allow the formation of causal relationships in the long run. The research is based on the self-reported information of the questionnaires, which can be subjective and biased in terms of responses. The model did not take into account external factors like institutional funding, policy variation, and the quality of infrastructure, which can affect the learning outcomes. The research only considers higher education, and this excludes primary, secondary and corporate learning settings. Longitudinal designs should be used in future research to embrace changes in learning behavior with time. It is also advised that comparative cross country studies be carried out to test the model in various education systems. Also, the variables of adaptive learning analytics based on AI and emotional engagement should be incorporated in future research to add explanatory power. The mixed-method approach may be also an option to obtain more qualitative data about the experiences of learners in the immersive environment. Moreover, future studies can generalize this model to vocational and corporate training ecosystems to determine its greater applicability in lifelong learning settings.

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