# Digital Learning Technology Integration in Tourism Education: A Design-Based Research Study

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Abstract: The rapid digital transformation of the tourism industry has increased the need for specialists with applied digital competencies and practice-oriented professional skills. This study examines the integration of applied digital learning technologies into tourism education using a design-based research approach and a single-group mixed-methods design. The proposed training model combined Moodle 3.11, practice-oriented digital modules, and browser-based virtual/interactive service-scenario simulations. The empirical implementation involved 48 undergraduate tourism students and 6 instructors over one academic semester. Pre-test and post-test results showed an improvement in mean learning scores from 61.4 to 78.9 ($p < 0.001$). A supplementary exploratory regression model indicated positive associations between competency development and LMS task completion, simulation engagement, and interaction frequency (R-squared = 0.64). Because the study used a small sample and no control group, these results are interpreted as within-group learning gains and indicative associations rather than definitive causal effects. Qualitative survey and observation evidence further indicated stronger engagement, practical readiness, and positive perceptions of the digital learning environment. The study contributes a scalable applied digital training framework for aligning tourism education with industry-oriented digital workflows while identifying the need for future controlled and larger-sample validation.

## 1 INTRODUCTION

The rapid digitalization of the tourism industry has led to the widespread adoption of applied information technologies, including digital booking platforms, virtual tour systems, customer relationship management (CRM) software, and data-driven service optimization tools [1], [2]. As tourism enterprises increasingly operate within digitally integrated environments, the professional training of tourism specialists must be aligned with applied IT-based workflows and real-world technological practices.

In higher education, however, tourism training programs often remain focused on theoretical instruction and general digital literacy, while the systematic use of applied digital learning technologies is limited [3]. This imbalance results in a significant gap between the professional competencies developed during academic training and the applied digital skills required by employers in the tourism sector. Graduates frequently lack practical experience in using industry-oriented digital platforms, virtual environments, and simulation-based decision-support systems [4].

Existing research emphasizes the importance of digital transformation in education, yet insufficient attention is paid to the applied IT dimension of professional training in tourism. In particular, there is a lack of methodological models that integrate applied digital learning technologies-such as browser-based virtual simulations, interactive

service-scenario systems, and digital project-based platforms-into the formation of occupation-specific competencies [5], [6]. This constitutes a clear research gap in the context of practice-oriented tourism education.

Applied digital learning technologies enable the modeling of real tourism service processes and support experiential learning in virtual and data-driven environments. Through the use of browser-based virtual simulations, digital service platforms, and interactive learning systems, students can acquire professional skills, technological competence, and decision-making abilities under conditions close to actual industry practice [7]. Such approaches correspond to the applied IT orientation required by contemporary education and innovation frameworks.

Comparable applied-digital studies in transport and infrastructure contexts show that computational modeling and digital risk-matrix workflows can transform operational observations into decision-support evidence for professional and organizational decision-making [8], [9].

The aim of this study is to examine the effectiveness of applied digital learning technologies in enhancing the professional training of tourism specialists. The objectives of the study are: (1) to analyze challenges in aligning tourism education with applied IT requirements; (2) to identify key professional competencies demanded by digitally intensive tourism environments; (3) to assess the pedagogical potential of applied digital learning technologies; and (4) to propose practical recommendations for integrating applied IT solutions into tourism education programs.

## 2 LITERATURE REVIEW AND THEORETICAL BACKGROUND

International research indicates that the digital transformation of tourism education has emerged as a strategic response to the increasing technological sophistication and platform-based organization of the tourism industry. Recent studies highlight that the rapid diffusion of digital platforms, data-driven services, and intelligent systems has fundamentally altered the competency requirements for tourism professionals, necessitating corresponding changes in higher education curricula [2], [10].

Empirical evidence further suggests that applied information technologies have evolved from auxiliary tools into core infrastructural elements of tourism service design, management, and value co-creation. Research on digital tourism ecosystems demonstrates that contemporary tourism operations rely heavily on interconnected digital platforms, real-time data exchange, and technology-enabled service innovation, which directly influences the structure and content of professional training programs [1], [2], [10]. Consequently, higher education institutions are increasingly required to integrate applied IT solutions into tourism education in order to ensure graduates' readiness for digitally intensive service environments.

Recent studies focus on the pedagogical use of digital platforms, virtual environments, and simulation technologies in tourism education. Kim and Hall's systematic review highlights that virtual reality (VR) and augmented reality (AR) technologies significantly improve students' experiential learning and professional engagement when applied in tourism-related courses [5]. Similarly, research on smart tourism destinations demonstrates that digital ecosystems require specialists who are capable of operating within data-driven and platform-based service models, reinforcing the need for applied IT-oriented training approaches [2], [10].

In addition, recent empirical studies emphasize that the effectiveness of digital technologies in tourism education depends not on their mere availability, but on their pedagogically grounded integration into competency-based curricula. Research by Radianti et al. demonstrates that immersive and simulation-based digital environments yield positive learning outcomes only when aligned with clear instructional objectives and professional task design, highlighting the importance of methodological coherence in applied digital learning implementations [11]. Similarly, Makransky and Petersen provide meta-analytic evidence that technology-enhanced experiential learning environments significantly improve skill acquisition when cognitive load and instructional scaffolding are systematically managed [6].

Furthermore, studies focusing on digital pedagogy in higher education indicate that learning management systems and virtual learning platforms contribute most effectively to professional training when combined with active learning strategies, formative assessment, and learning analytics. According to García-Peñalvo, digital transformation in education should be understood as a pedagogical innovation process rather than a purely technological shift, requiring instructors to redesign learning activities around applied digital tools and professional competencies [12]. In the context of

tourism education, this implies that applied digital learning technologies must be embedded into authentic service scenarios and industry-oriented tasks to achieve measurable competency development.

However, the analysis of international literature reveals that many studies primarily address technological potential rather than structured pedagogical integration. This gap indicates that while digital tools are widely discussed, their systematic application in competency formation remains insufficiently explored, particularly in tourism education programs.

## 2.1 Concept of Applied Digital Learning Technologies

Applied digital learning technologies are understood as IT-based educational tools and environments that directly support practice-oriented learning and professional skill development. Unlike general e-learning systems, applied digital technologies focus on simulating real professional processes and enabling students to perform industry-relevant tasks in digital environments. These technologies include learning management systems, virtual simulations, digital service platforms, and interactive e-learning systems that incorporate automation, data analytics, and user interaction.

LMS platforms are commonly used to organize learning content and assessment; however, their applied value depends on the integration of interactive and task-based modules. Browser-based virtual simulation environments allow students to model tourism service scenarios, customer interactions, and decision-making processes under controlled but realistic conditions [13]. E-learning platforms that support project-based and problem-oriented learning further enhance students' professional autonomy and technological competence [14].

From an applied IT perspective, these technologies enable the alignment of educational processes with industry-specific digital workflows, thereby strengthening the practical orientation of professional training.

## 2.2 Theoretical Foundations of Professional Training And Competency-Based Education

The theoretical foundation of this study is based on competency-based education and experiential learning theories. Competency-based education emphasizes the formation of measurable professional competencies that correspond to labor market requirements rather than the accumulation of theoretical knowledge alone. According to this approach, learning outcomes must reflect students' ability to perform professional tasks effectively in real or simulated environments.

Kolb's experiential learning theory further supports the use of applied digital technologies by emphasizing learning through experience, reflection, and active experimentation [13]. In tourism education, this theoretical framework justifies the integration of digital simulations and applied IT tools as mechanisms for transforming theoretical knowledge into practical competence. Digital learning environments thus function as mediators between academic instruction and professional practice.

## 2.3 Limitations of Existing Approaches

Despite the growing body of research on digital technologies in education, several limitations persist. First, many studies focus on isolated digital tools rather than comprehensive applied IT systems integrated into professional training models. Second, empirical evidence on the long-term impact of applied digital learning technologies on professional competency development in tourism remains limited. Third, existing approaches often lack clear methodological frameworks that link digital technologies with specific professional competencies.

These limitations indicate the need for further research that systematically examines applied digital learning technologies as integral components of professional training. Addressing these gaps requires the development of practice-oriented models that combine applied IT solutions with competency-based educational principles, particularly in the context of tourism education.

# 3 RESEARCH METHODOLOGY

This study employed a design-based research (DBR) approach combined with mixed methods in order to examine the effectiveness of applied digital learning technologies in the professional training of tourism specialists. The DBR framework was selected because it allows the iterative design, implementation, and evaluation of digital learning solutions within real educational settings. Quantitative data were used to measure changes in

students' professional competencies, while qualitative data provided insights into learning experiences and instructional effectiveness.

The research was conducted over one academic semester and consisted of three stages (Fig. 1): (1) design and integration of applied digital learning technologies into tourism courses; (2) implementation of digital learning modules within the instructional process; and (3) evaluation of learning outcomes and competency development.

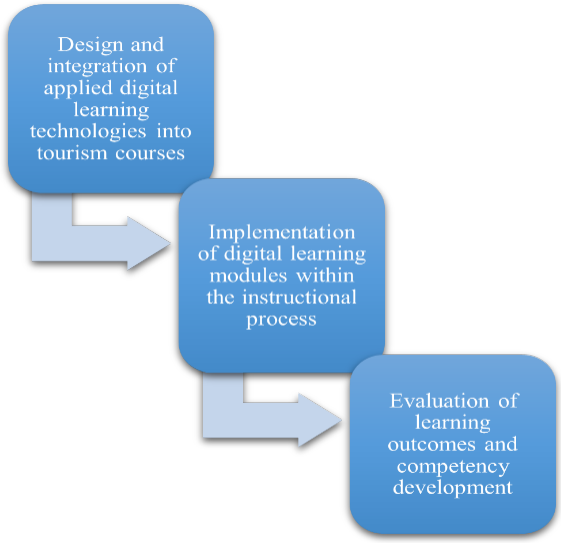


Figure 1: Research design and implementation stages conducted over one academic semester.

The study involved undergraduate tourism students and instructors from a higher education institution offering tourism-related programs. A total of 48 students participated in the experimental learning activities, while 6 instructors were involved in the design and facilitation of the digital modules. Student participation in this study was voluntary. All collected data were anonymized to ensure confidentiality. Informed consent was obtained from all participants, and the study protocol was approved by the institutional review board. Students were selected based on their enrollment in professional tourism courses, ensuring relevance to industry-oriented training. Instructors had prior experience in tourism education and basic proficiency in digital teaching tools.

Description of applied digital learning technologies

The applied digital learning environment was developed to support practice-oriented professional training and consisted of three interconnected components: Learning Management System, digital learning modules, and virtual/interactive learning tools.

The educational process was implemented using the Learning Management System (LMS) Moodle (version 3.11). LMS was used as the core infrastructure for organizing learning content, managing assignments, monitoring student progress, and collecting assessment data. The LMS enabled structured delivery of digital materials, automated testing, and analytics-based tracking of learner performance. Its applied value was enhanced through task-based activities aligned with professional tourism scenarios.

To avoid ambiguity regarding the virtual component, no head-mounted or proprietary immersive VR platform was used. The simulation component was implemented as browser-based interactive tourism-service scenarios delivered through Moodle 3.11. These scenarios reproduced customer interaction, service planning, and destination-presentation tasks within the same LMS environment used for assignments and analytics. Thus, the term virtual simulation in this study refers to structured interactive scenario-based learning rather than hardware-based immersive VR.

Digital learning modules were designed as practice-oriented units focusing on real tourism service processes, including customer interaction, service planning, and digital platform usage. Each module combined instructional content, applied tasks, and formative assessment activities. The structure and function of the applied digital technologies used in the study are summarized in Table 1.

Table 1: Applied digital learning technologies and their instructional functions.

| Digital technology | Instructional purpose | Professional skills developed |
|---|---|---|
| Learning Management System (LMS) | Content delivery, assessment, learning analytics | Digital literacy, task management |
| Digital learning modules | Practice-oriented learning tasks | Service planning, problem-solving |
| Browser-based virtual simulations | Moodle-based modeling of tourism service scenarios | Decision-making, customer interaction |
| Interactive tools | Engagement and collaborative learning | Communication, teamwork |

As summarized in Table 1, the applied environment combined Moodle-based content delivery, task-oriented digital modules, browser-based virtual simulation scenarios, and interactive collaboration tools. The virtual simulation component allowed students to practice decision-making in simulated customer service situations, explore virtual tourism destinations, and interact with digital service interfaces. These tools supported experiential learning and reduced the gap between theoretical instruction and professional practice.

Data collection methods

Multiple data collection methods were employed to ensure the reliability and validity of the findings. Knowledge and skills tests were administered before and after the intervention to measure changes in professional competencies. Surveys were used to collect students' perceptions of the effectiveness and usability of applied digital learning technologies. Additionally, structured observations were conducted during learning activities to assess student engagement, interaction, and application of digital tools in practice-based tasks.

The effectiveness of applied digital learning technologies was evaluated using clearly defined criteria and indicators. These included: (1) improvement in professional competency levels measured through test scores; (2) ability to perform applied digital tasks related to tourism services; (3) student engagement and participation in digital learning activities; and (4) instructors' assessments of students' readiness for professional practice. Quantitative indicators were complemented by qualitative analysis of survey responses and observational data.

The competency index (CI) was developed as an integrated quantitative measure of students' professional competency levels across four key dimensions: digital service operation (DS), problem-solving (PS), customer interaction (CX), and decision-making (DM). Each dimension was assessed using standardized evaluation criteria, and the overall competency index was calculated as the arithmetic mean of these components:

$$CI = (DS + PS + CX + DM) / 4.$$

All components were measured on a normalized scale ranging from 0 to 1, ensuring comparability across indicators. The use of an aggregated index allowed for a comprehensive assessment of students' professional competency development within applied digital learning environments.

The independent variables included in the regression model were operationalized as follows. LMS usage intensity (LMS) was measured as the percentage of completed digital tasks and assignments within the learning management system. Virtual simulation engagement (SIM) was quantified based on the number of completed simulation sessions and the level of participation in scenario-based activities. Interaction frequency (INT) was measured as the average number of meaningful interactions per week within digital learning modules, including forum discussions, collaborative tasks, and feedback exchanges.

To ensure the reliability of the measurement instruments, internal consistency was evaluated using Cronbach's alpha coefficient. The obtained value exceeded the acceptable threshold of 0.7, indicating satisfactory reliability of the scales used for assessing competency dimensions and engagement indicators.

# 4 RESULTS AND DISCUSSION

The effectiveness of the proposed applied digital training model was evaluated by comparing students' learning outcomes and professional competency levels before and after the implementation of applied digital learning technologies. Quantitative analysis was conducted using pre-test and post-test scores, competency assessment rubrics, and performance indicators collected through the LMS.

Table 2 presents the pre-test and post-test learning outcomes used to evaluate within-group change. The post-test mean score ($M = 78.9$, $SD = 7.5$) was substantially higher than the pre-test mean score ($M = 61.4$, $SD = 8.2$). The paired-samples t-test revealed a statistically significant difference between the two measurements ($t = 9.87$, $p < 0.001$), indicating a measurable improvement after the digital-learning intervention.

Table 2: Comparison of pre-test and post-test learning outcomes.

| Measure | N | Mean | Standard Deviation (SD) | t-value | p-value |
|---|---|---|---|---|---|
| Pre-test | 48 | 61.4 | 8.2 | | |
| Post-test | 48 | 78.9 | 7.5 | 9.87 | < 0.001 |

Professional competency levels were assessed across four key dimensions: digital service operation, problem-solving, customer interaction, and decision-making. The average competency index increased from 0.58 to 0.81, reflecting a 39.7% improvement over the experimental period. These results demonstrate that the applied digital training model contributes not only to knowledge acquisition but also to measurable professional skill development.

To evaluate the impact of applied digital learning technologies on professional competency development, a multiple linear regression model was employed:

$$CI_i = \beta_0 + \beta_1 LMS_i + \beta_2 SIM_i + \beta_3 INT_i + \varepsilon_i, \quad (1)$$

where: *CI* – competency index; *LMS* – LMS usage intensity; *SIM* – virtual simulation engagement; *INT* – interaction frequency in digital learning modules.

Given the exploratory design, the relatively small sample ($n = 48$), and the absence of a control group, the regression results should be interpreted as indicative associations rather than causal estimates. The model was used to identify the relative contribution of applied digital learning components to competency development within the studied educational context, not to build a predictive model for generalization. Because the sample is small for multivariable modeling, the reported $R^2$ value may be sensitive to overfitting and should be validated in future studies using larger samples, independent cohorts, or cross-institutional replication.

The regression results indicate a strong explanatory power of the exploratory model ($R^2 = 0.64$). Virtual simulation engagement ($\beta_2 = 0.42$, $p < 0.01$) had the highest association with competency development, followed by LMS-based task completion ($\beta_1 = 0.31$, $p < 0.05$). Interaction frequency also showed a positive but moderate association ($\beta_3 = 0.19$, $p < 0.10$).

These findings indicate that applied digital components, particularly simulation-based learning tools, were positively associated with professional competency development in the studied group. However, the single-group design means that the observed improvement cannot be attributed exclusively to the intervention without further controlled validation.

The obtained results are consistent with recent international studies emphasizing the effectiveness of applied digital learning environments in higher education. Prior research has shown that simulation-based and technology-enhanced learning significantly improves students' practical skills and engagement levels in professional education contexts [11]. The present study extends these findings by providing econometric evidence of the relationship between specific applied digital tools and competency development in tourism education.

Unlike earlier studies that primarily relied on qualitative or perception-based evaluations, this research integrates quantitative and econometric methods, thereby strengthening the empirical basis for applied digital learning models. The results demonstrate that structured integration of LMS analytics, digital modules, and virtual simulations yields higher competency gains than isolated or supplementary digital tool usage.

From a practical perspective, the results highlight the value of integrating applied digital learning technologies into tourism education curricula. The proposed model can be adopted by higher education institutions to enhance graduates' professional readiness, reduce adaptation time in the workplace, and align educational outcomes with industry digitalization trends.

However, several limitations should be acknowledged. First, the sample size was limited to one institution and 48 students, which may affect the generalizability of the results and increases the risk of model overfitting in regression analysis. Second, the study used a single-group pre-test/post-test design without a parallel control group, so the observed learning gains should be interpreted as within-group changes rather than definitive causal effects. Third, the study focused on short-term competency gains; long-term impacts on professional performance were not assessed. Future research should involve larger samples, control groups, longitudinal designs, and cross-institutional comparisons to further validate the effectiveness of applied digital training models.

# 5 CONCLUSIONS

This study investigated the effectiveness of applied digital learning technologies in enhancing the professional training of tourism specialists within higher education institutions. Grounded in competency-based education theory, experiential learning theory (Kolb), and digital transformation frameworks in tourism, the research adopted a design-based research (DBR) methodology combined with a mixed-methods approach. This methodological integration enabled not only the development of an applied digital training model but also its iterative testing, refinement, and empirical validation within authentic educational settings.

The applied digital training model was designed to align pedagogical processes with the structural and technological transformations occurring in the tourism industry, including smart tourism systems, digital customer engagement platforms, data-driven destination management, and virtual service environments. By embedding virtual simulations, learning management systems (LMS), scenario-based problem-solving tasks, and interactive digital modules into core tourism subjects, the model aimed to reduce the persistent gap between theoretical instruction and professional practice. From a scientific standpoint, the findings provide robust empirical evidence that systematic and pedagogically structured integration of applied digital learning technologies significantly enhances both academic performance and professional competency development. Quantitative analysis revealed statistically significant improvements in competency indices across digital service operation, problem-solving, customer interaction, and decision-making dimensions. Importantly, econometric modeling demonstrated that browser-based virtual simulations and LMS-based applied tasks exerted the strongest predictive influence on competency formation. These results extend prior research by providing econometric evidence of a statistically significant association between specific applied digital components and measurable professional training outcomes in tourism education. The study also contributes theoretically by operationalizing digital competence within the context of tourism professional training. Rather than treating digital tools as supplementary instructional aids, the research conceptualizes them as structural elements of a competency-oriented educational ecosystem. This ecosystem integrates digital technologies, pedagogical strategies, assessment mechanisms, and industry-relevant scenarios into a coherent methodological framework. Such systemic integration differentiates the proposed model from fragmented or technology-centered approaches that lack pedagogical alignment. From a practical perspective, the study underscores the strategic importance of applied digital learning technologies in modern tourism education. The tourism sector is increasingly characterized by digital booking systems, AI-driven customer service, smart destination management, big data analytics, and immersive virtual marketing. Preparing future specialists without embedding these technologies into the learning process risks producing graduates who are theoretically informed but professionally underprepared. The proposed applied digital training model offers higher education institutions a structured and potentially scalable framework for enhancing professional readiness, strengthening practice-oriented instruction, and responding effectively to ongoing digital transformation within the tourism industry. The implementation of the proposed methodology positively influences educational quality through multiple mechanisms. First, it increases student engagement by shifting from passive content consumption to active, simulation-based participation. Second, it enables competency-based assessment through digital performance tracking and analytics-driven evaluation. Third, it supports data-informed instructional decision-making, allowing educators to monitor learning trajectories and adjust instructional interventions accordingly. Collectively, these factors contribute to improved instructional effectiveness, measurable skill acquisition, and enhanced professional confidence among students. Furthermore, the model facilitates the development of transversal competencies such as critical thinking, digital problem-solving, collaborative decision-making, and adaptive learning-skills that are increasingly essential in technology-intensive tourism environments. By simulating real-world professional scenarios, students develop not only technical skills but also situational judgment and strategic reasoning aligned with industry expectations. Despite its contributions, the study acknowledges certain limitations. The sample size was confined to specific institutional contexts, which may limit generalizability across diverse educational systems. The duration of the experimental intervention, although sufficient to detect short-term effects, does not fully capture long-term competency retention or professional workplace performance. Additionally, variations in digital infrastructure and faculty readiness may influence implementation outcomes in other institutional environments.

Future research should prioritize longitudinal designs to evaluate the sustained impact of applied digital training models on graduates' career trajectories and professional effectiveness. Comparative cross-institutional studies would further strengthen external validity. Moreover, future investigations should explore the integration of advanced technologies-including artificial intelligence-driven adaptive learning systems, predictive learning analytics, augmented and virtual reality environments, and intelligent tutoring systems-to enhance personalization, scalability, and real-time feedback mechanisms in tourism education.

In conclusion, the results indicate that applied digital learning technologies can function not merely as instructional enhancements but as strategic instruments for transforming professional education in tourism. Their systematic integration into competency-based pedagogical models was associated with improved learning outcomes, stronger alignment with industry demands, and support for sustainable innovation in higher education. The study provides a theoretically grounded and practically applicable framework that requires further validation through controlled, larger-sample, and longitudinal research.

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