Int. j. adv. multidisc. res. stud. 2026; 6(4):340-345

Received: 19-05-2026
Accepted: 29-06-2026

International Journal of Advanced Multidisciplinary Research and Studies

ISSN: 2583-049X

Building a Digital Learning Resource Ecosystem: A Practical Initiative of an Online Anatomy Library in Higher Education

[1] **Phan Thanh Viet,** [2] **Tran Thai Ngoc**
[1, 2] Ho Chi Minh City University of Physical Education and Sports, Ho Chi Minh City, Vietnam

DOI: https://doi.org/10.62225/2583049X.2026.6.4.6606
Corresponding Author: **Phan Thanh Viet**

Abstract
In the era of rapid global digital transformation, developing a robust digital learning resource ecosystem has become a paramount strategy for higher education institutions. This study introduces a comprehensive framework for a digital learning resource ecosystem and evaluates a practical initiative—the construction of an online learning resource repository for the Anatomy module at the Ho Chi Minh City University of Physical Education and Sports. The research employed a three-phase methodology involving the systematic design of 22 digital lectures, the deployment of a cloud-based infrastructure, and operational management for the K20 undergraduate physical education cohort during the 2025–2026 academic year. Evaluation of student feedback revealed highly positive outcomes: 84.00% of respondents rated the learning quality as "Good" or "Very Good," and 79.62% confirmed the high effectiveness of the digital resources. Furthermore, 99.36% of participants acknowledged the crucial role of multimedia materials in facilitating their learning. Based on these empirical findings and a comprehensive literature review, this study proposes a structural framework for a digital learning resource ecosystem comprising four sequential layers: foundational content, learning materials and experiential tools, interactive environments, and administration and analysis. These findings provide significant insights into effective digital transformation strategies in higher education.

Keywords: Digital Learning Ecosystems, Educational Digital Transformation, Higher Education, Anatomy Education, Learning Management Systems

1. Introduction

Digital transformation in education has accelerated globally, fundamentally shifting pedagogical paradigms toward digital environments where big data and digital learning resources occupy central roles in educational innovation. However, navigating the nuances of digital transformation and establishing the necessary structural prerequisites remain ongoing challenges that must evolve alongside technological advancements [2]. In Vietnam, the government has identified educational digital transformation as a paramount strategic breakthrough. Specifically, national policy frameworks emphasize the imperative of building smart educational platforms, developing e-textbooks, and integrating artificial intelligence into pedagogy and educational management [1, 3].

Within this context, digital learning resources are conceptualized as digitized educational materials designed with specific architectures and pedagogical scenarios. Stored on electronic devices or cloud networks, these resources encompass diverse formats, including texts, datasets, audio, video, interactive software, and hybrid modalities. Compared to traditional printed media, digital resources offer superior diversity, enhanced interactivity through dynamic navigation, and rapid, real-time updates. Despite these advantages, operational challenges such as reliance on robust internet connectivity and potential student distraction persist.

Prior to this investigation, teaching materials for the Anatomy module at the Ho Chi Minh City University of Physical Education and Sports (UPES) were regularly updated by the faculty but lacked a systematic digital infrastructure, thereby limiting accessibility and engagement for the K20 undergraduate physical education cohort (admitted in 2025). To address this gap, this study aims to construct an online digital repository for the Anatomy module as a practical initiative. Concurrently, it theoretically conceptualizes a comprehensive, four-layer digital learning resource ecosystem to serve as a scalable reference architecture for smart higher education institutions.

2. Materials and Methods

To evaluate the implementation and efficacy of the digital learning resource repository for the Anatomy module, a three-phase operational and methodological framework was executed.

Phase 1: Instructional Design and Material Development. A comprehensive set of 22 digital lectures was systematically developed in alignment with the institutional Anatomy syllabus. These primary materials were supplemented by 10 curated academic references and an extensive repository of high-resolution anatomical illustrations to enhance visual learning.

Phase 2: Cloud-Based Repository Architecture. A structured, multi-tiered digital architecture was established leveraging a secure cloud storage platform. This centralized cloud infrastructure provided unified, high-availability access via encrypted, permission-controlled sharing protocols to ensure data integrity and institutional compliance.

Phase 3: Deployment and Operational Management. The digital repository was deployed for the K20 undergraduate physical education cohort ($N = 157$) during the first semester of the 2025–2026 academic year. Instructors provided standardized access guidelines and continuously monitored, calibrated, and updated the resources based on real-time instructional feedback and pedagogical requirements.

To empirically assess the intervention, a quantitative descriptive survey design was administered to the participating cohort upon module completion. The survey instrument utilized a structured questionnaire to capture student perceptions regarding the quality, technological effectiveness, and pedagogical responsiveness of the digital resources. The collected empirical data were subsequently subjected to statistical analysis to provide a baseline for scalable institutional models.

3. Results and Discussion

3.1 Architectural Deployment and Content Structure of the Online Anatomy Repository

The digital learning resource ecosystem at UPES was systematically initiated within the Anatomy module for the K20 undergraduate cohort. Prior to this initiative, pedagogical materials for this foundational scientific module were frequently updated by the faculty to reflect current anatomical and kinesiological findings; however, they lacked a centralized, systematized digital framework. This infrastructural deficit limited students' capacity for proactive academic engagement and restricted continuous access to vital educational resources outside conventional lecture hours. In contemporary higher education, the absence of a centralized digital infrastructure presents a significant barrier to self-directed learning, particularly in complex biomedical disciplines like human anatomy, which require continuous, iterative engagement with elaborate informational schemas. Relying solely on fragmented, temporally bound physical materials is pedagogically suboptimal. Therefore, the transition toward a structured digital learning repository constitutes a fundamental paradigm shift in how foundational scientific knowledge is curated, distributed, and internalized by digitally-native undergraduate learners.

To rectify these historical infrastructural limitations, the digital ecosystem was deployed utilizing a scalable cloud-based architecture via the Google Drive platform. This architectural choice ensured ubiquitous, multi-device access and high operational reliability for the entire cohort, mitigating geographic and socio-economic technical constraints. From an institutional IT governance perspective, migrating resource management from vulnerable localized servers to high-availability cloud platforms enhances infrastructural scalability, automated data redundancy, and fault tolerance.

The implementation of this technological architecture is framed within the Technology Acceptance Model (TAM) posited by Davis [4], which states that user behavioral intention to adopt an information system is determined by Perceived Ease of Use (PEOU) and Perceived Usefulness (PU). By leveraging a universally recognized, intuitive platform like Google Drive, the design team maximized PEOU. Students were not required to navigate complex institutional VPNs or master proprietary interfaces, as the platform aligned with their pre-existing digital literacy. Concurrently, PU was enhanced by providing 24/7 asynchronous access to core materials, which accommodates the erratic schedules typical of physical education students who must balance rigorous theoretical coursework with demanding athletic training regimens. Consequently, utilizing TAM as a deployment philosophy facilitated a low-friction technological adoption phase.

Following the establishment of this cloud-based foundation, the digital repository was systematically populated with three primary categories of instructional resources aligned to complement traditional in-person pedagogy: standardized digital lectures, advanced supplementary academic references, and a curated collection of high-resolution anatomical illustrations. The curation of these multimodal materials followed a deliberate instructional design process rooted in cognitive science. Table 1 delineates the specific composition, quantitative distribution, pedagogical functions, and file formats of the deployed repository during the first semester of the 2025–2026 academic year.

Table 1: Content distribution within the Anatomy digital learning repository

Resource Category	Quantity	Pedagogical Function	Format / File Type
Standardized Digital Lectures	22 modules	Core knowledge dissemination; enabling micro-learning and self-paced study.	PDF, PPTX
Supplementary References	10 documents	Extending theoretical frameworks; bridging foundational anatomy with applied physical education.	PDF, DOCX
Curated Anatomical Illustrations	1 comprehensive set	Enhancing spatial understanding of human musculoskeletal and nervous systems.	JPEG, PNG
Assessment & Evaluation Tools	1 unified test (KT.01)	Formative assessment to gauge knowledge retention and comprehension.	PDF / Integrated forms
Student Feedback Surveys	2 datasets	Gathering empirical data on ecosystem effectiveness and user satisfaction.	Google Forms / Sheets

Within the repository, foundational anatomical knowledge was facilitated through 22 standardized digital lecture modules in secure PDF and PPTX formats, engineered to enable micro-learning and self-paced study. The application of these instructional design principles aligns with Cognitive Load Theory (CLT) developed by Sweller [5], which posits that working memory has a constrained capacity for processing novel information. Anatomy students frequently experience intrinsic cognitive overload due to the volume of Latinate terminology, multi-dimensional spatial orientations, and complex physiological mechanisms. Traditional didactic lectures presenting dense blocks of information within rigid temporal constraints often exacerbate extraneous cognitive load, leading to learner fatigue and diminished long-term retention.

Conversely, the 22 digital modules deconstructed the anatomical curriculum into discrete, manageable micro-instructional units. This segmented approach mitigated extraneous cognitive load, allowing the K20 cohort to autonomously regulate their learning velocity. Students could dynamically pause, annotate, and repeatedly review complex topics—such as the neurovascular pathways of the upper limb or the biomechanical articulations of the appendicular skeleton—until conceptual mastery and stable schema formation were achieved. Furthermore, this self-paced modality accommodated neurodiversity within the student body, ensuring equitable engagement with complex materials.

To complement the core lectures, the repository housed 10 specific supplementary academic reference documents in PDF and DOCX formats. These texts served to bridge the gap between theoretical anatomical science and the applied field of physical education. In a specialized sports science institution like UPES, human anatomy must connect to the kinetic realities of human movement, athletic performance optimization, and evidence-based kinesiological principles. These 10 supplementary references served as an intellectual bridge linking macroscopic biology to athletic training, injury prevention, and sports rehabilitation protocols. By engaging with these advanced texts, students ascended the hierarchical levels of Bloom's Taxonomy, transitioning from lower-order factual remembering to higher-order application, critical analysis, and physiological evaluation. For instance, foundational knowledge regarding the origin, insertion, and innervation of the quadriceps femoris—acquired via the digital lectures—was translated through supplementary texts into immediate applications regarding biomechanical load distribution during sprinting or rehabilitative protocols following an anterior cruciate ligament (ACL) rupture. This integration also fostered a culture of Evidence-Based Practice (EBP) among future physical educators.

A visually indispensable cornerstone of the repository was the strategic inclusion of a comprehensive set of anatomical illustrations in high-resolution JPEG and PNG formats. These visual resources were designed to enhance students' spatial understanding of the musculoskeletal and nervous systems. Because human anatomy is an inherently visual, three-dimensional discipline, reliance on traditional, text-heavy descriptions is insufficient for developing the spatial cognition required to comprehend structural relationships within the body. The integration of high-resolution imagery operationalizes Dual Coding Theory (DCT) proposed by Paivio [6], which asserts that the human cognitive architecture processes visual and verbal information through separate, interconnected channels.

According to DCT, when dense linguistic descriptions in text-based lectures are paired with precise visual representations, the probability of long-term knowledge retention and rapid retrieval is significantly increased. These high-fidelity visual assets empowered students to mentally rotate complex structures and map the branching trajectories of peripheral nerves and major blood vessels. In institutional contexts where direct access to physical, high-cost cadaveric dissection laboratories was logistically or ethically constrained, these high-resolution digital illustrations served as the primary cognitive interface for developing professional-grade anatomical spatial intelligence.

To systematically monitor comprehension levels, the repository incorporated a unified testing instrument designated as KT.01. Delivered via universally compatible PDF documents and integrated digital response forms, this tool functioned as a formative assessment mechanism embedded within the ecosystem. The integration of digital formative assessment represents a departure from traditional, strictly summative evaluation paradigms. As articulated by Black and Wiliam [7], formative assessment—characterized by continuous, low-stakes testing that provides rapid feedback—yields substantial improvements in student learning outcomes. While summative assessments occur at the conclusion of an instructional period for grading purposes, formative tools like the KT.01 test were embedded into the daily learning workflow to provide immediate, diagnostic feedback. This continuous feedback loop is essential for fostering self-regulated learning (SRL) behaviors.

When engaging with the digital test, students received empirical data regarding their current level of mastery, allowing them to identify specific knowledge gaps or factual errors in real time. This capability empowered learners to proactively remediate deficiencies by returning to specific lecture modules or visual illustrations. Furthermore, these integrated digital forms generated a continuous stream of learning analytics, enabling faculty to identify prevalent misconceptions across the cohort and dynamically adjust subsequent in-person lectures or targeted pedagogical interventions.

Finally, the repository's infrastructure included two data sets derived from student feedback surveys administered anonymously via Google Forms and aggregated in Google Sheets for analysis. The inclusion of these data sets was designed to gather empirical data concerning the ecosystem's operational effectiveness, technological reliability, and user satisfaction. In contemporary instructional design, the deployment of a digital learning environment is viewed as an iterative process of systemic refinement rather than a static event. The collection of user experience (UX) and learner experience (LX) data is fundamental to executing Continuous Quality Improvement (CQI) principles. By analyzing multi-dimensional student feedback, the instructional design team transitioned from intuition-based resource management toward an evidence-based pedagogical design philosophy. These survey data sets empowered faculty to evaluate technological affordances, identify digital friction points within the infrastructure, and ensured that the digital learning resource ecosystem remained an agile, responsive entity capable of adapting to the evolving academic and technological expectations of 21st-century undergraduate students.

3.2 Empirical Evaluation of Learning Quality and Student Satisfaction

To evaluate the pedagogical impact of the digital learning resource repository, a quantitative survey was administered to the participating cohort upon completion of the Anatomy module. The empirical evaluation focused on three primary dimensions: (1) the perceived quality of the learning experience, (2) the technological and pedagogical effectiveness of the digital resources, and (3) the responsiveness of the multimodal materials to specific academic requirements. The aggregated descriptive statistics are presented in Table 2.

Table 2: Student evaluation of the digital learning resource ecosystem based on quality, effectiveness, and responsiveness

Evaluation Variable	Assessment Criteria	Percentage of Responses (%)
Variable 1: Quality of learning	Very Good	35.00%
	Good	49.00%
	Normal	16.00%
	Poor / Very Poor	0.00%
Variable 2: Learning Effectiveness	Effective & Very Effective	79.62%
	Neutral / Ineffective	20.38%
Variable 3: Resource Responsiveness	Agreed (Met study requirements)	99.36%
	Disagreed (Did not meet requirements)	0.64%

As illustrated in Table 2, the perceived quality of learning facilitated by the digital repository yielded highly favorable assessments. Specifically, 84.00% of the respondents evaluated the learning quality positively, with 35.00% rating it as “Very Good” and 49.00% as “Good.” The remaining 16.00% of participants perceived the quality as “Moderate,” while no negative ratings were recorded. This distribution suggested a successful transition from traditional, static pedagogical methods to an asynchronous digital learning environment. The high-quality indicators demonstrated that the systematic organization of digital infrastructure enhanced student autonomy, enabling proactive engagement with the knowledge base prior to synchronous classroom sessions—a finding that aligns with the core principles of the flipped classroom model.

Regarding the second variable, 79.62% of the students affirmed that utilizing the cloud-based repository was either “Effective” or “Very Effective.” Prior to this intervention, the lack of a centralized digital storage framework limited resource accessibility and student engagement. By consolidating the 22 digital lectures and 10 supplementary references into a unified cloud repository, the ecosystem mitigated physical and temporal barriers to instruction. The data indicated that students interacted with the academic content at their own pace, thereby fostering continuous, self-directed learning behaviors and allowing for timely pedagogical interventions by the instructional faculty.

The highest consensus in the survey was observed regarding the responsiveness of the provided resources, which garnered a 99.36% agreement rate. The respondents confirmed that the inclusion of diverse multimedia materials—specifically high-resolution anatomical illustrations, instructional videos, and supplementary references—met the precise study requirements for each anatomical topic. In biomedical education, spatial visualization of human anatomical structures is paramount; traditional text-heavy media frequently fail to convey these complex multi-dimensional relationships. This high responsiveness score suggested that multimedia-rich digital formats directly addressed the cognitive requirements of the learners, thereby facilitating spatial comprehension and knowledge retention.

3.3 Theoretical Integration: The Four-Layer Digital Resource Ecosystem Framework

Synthesizing the empirical outcomes of the online Anatomy repository with broader theoretical paradigms of educational digital transformation, this study conceptualizes a scalable, interactive Four-Layer Digital Learning Resource Ecosystem applicable to modern higher education institutions. The necessity for such an ecosystem is underscored by the contemporary expansion of knowledge and the emergence of global data science platforms, which prompt educational systems to migrate toward digital environments where big data and digital resources occupy central roles in pedagogical innovation. In the specific context of Vietnam, this conceptualization aligns with strategic national directives and policy frameworks [1, 3] that mandate the development of smart educational platforms, digital textbooks, and the integration of artificial intelligence into educational management and pedagogical methodologies.

However, as highlighted in contemporary literature, a fundamental distinction must be maintained between mere “digitization” (the conversion of physical documents into digital formats) and true “digital transformation.” The act of uploading a digital lecture to a cloud server represents only the initial stage of digitization. A fully realized ecosystem is established only when these diverse digital resources dynamically interact, seamlessly connect, and generate augmented cognitive value for learners. Therefore, based on the practical initiative implemented for the K20 undergraduate cohort in Physical Education, this study proposes a structural framework comprising four sequential and interdependent layers, with the anatomy initiative serving as a foundational proof-of-concept.

Layer 1: Foundational Content

This primary layer constitutes the standardized core knowledge, acting as the baseline intellectual material for the ecosystem. In this study, the foundational layer was operationalized through the deployment of 22 structured digital lectures, 10 supplementary academic references, and a curated collection of anatomical illustrations. In traditional educational models, the physical library serves as a static core, with printed textbooks imposing geographic and temporal limitations. Conversely, within this digital ecosystem, the foundational content layer ensures that knowledge circulates through digital networks, mitigating accessibility barriers and reducing the logistical costs associated with print production and physical storage.

The digital lectures within this layer are engineered to facilitate modern pedagogical paradigms, including micro-learning and the flipped classroom. Micro-learning deconstructs complex biomedical information into focused, manageable cognitive units, thereby reducing the intrinsic cognitive load frequently experienced by students studying human anatomy. Concurrently, the flipped classroom model shifts the pedagogical dynamic from passive reception to active engagement. By providing continuous, on-demand access to foundational content, students are enabled to independently acquire theoretical knowledge prior to attending synchronous sessions. This autonomous preparation allows instructors to reallocate valuable classroom time toward higher-order cognitive activities, practical applications, and collaborative problem-solving. Ultimately, the foundational content layer transforms the traditional textbook into an interactive entity, transitioning the learner's role from a passive recipient to an active constructor of knowledge.

Layer 2: Learning Materials and Experiential Tools

While the foundational layer supplies essential theoretical knowledge, Layer 2 aims to elevate passive consumption into multi-sensory educational experiences. In the current implementation of the Anatomy repository, this layer utilized high-resolution anatomical imagery to enhance spatial comprehension. However, the strategic evolution of this layer necessitates the integration of immersive technologies, specifically Virtual Reality (VR) and Augmented Reality (AR).

Traditional pedagogical models, despite utilizing two-dimensional anatomical charts and illustrative videos, possess limitations dictated by static technological infrastructures. Anatomy is fundamentally a spatial and multi-dimensional science; the comprehension of complex musculoskeletal structures, neurovascular pathways, and physiological mechanisms requires sophisticated spatial intelligence. In higher education, a significant challenge is the high financial and logistical cost associated with operating physical laboratory facilities and cadaveric dissection labs. The integration of VR and AR into the digital ecosystem addresses these systemic bottlenecks. VR creates simulated digital environments that allow students to explore anatomical structures, biomechanical movements, and temporal physiological events in a controlled, risk-free setting. AR further enhances this by overlaying multi-dimensional digital models onto the real physical environment, offering high interactivity. By transitioning from purely theoretical instruction to sensory-rich experiences, Layer 2 enhances deep cognitive engagement and spatial memory retention.

Layer 3: Interactive Environments and Digital Assessment

Serving as the connective tissue of the ecosystem, the third layer bridges learners, instructors, and peers, transforming a data repository into a collaborative learning hub. In traditional educational environments, students often encounter psychological barriers—such as the fear of negative evaluation—which can inhibit participation in academic discourse. Digital discussion forums integrated within this layer provide a vital solution. The asynchronous nature of these platforms mitigates these barriers, expanding students' safe zones and encouraging them to discuss complex topics, engage in critical thinking, and co-create knowledge. Through these online interactions, students refine their digital communication competencies, practice logical argumentation, and develop collaborative skills essential for the modern workforce. Within this architectural framework, if digital lectures provide the informational substance, the interactive environments serve as the functional mechanism that ensures operational sustainability and pedagogical effectiveness.

Furthermore, this interactive layer redefines the concept of assessment. Within the digital ecosystem, assessment is transformed from a summative, end-of-term metric into a continuous, formative tool utilized throughout the instructional process. By integrating digitized, gamified assessment applications and customized web-based forms directly into the learning workflow, students receive immediate feedback on their comprehension levels. This immediate feedback loop enables learners to identify specific knowledge gaps and engage in targeted remediation. Simultaneously, it provides instructors with real-time pedagogical insights, allowing them to monitor task completion rates and address common conceptual misunderstandings within the student cohort.

Layer 4: Administration and Analysis

The apex of the framework focuses on data governance and predictive analytics. The foundational infrastructure required to operationalize this layer is the Learning Management System (LMS). The LMS functions as the operational core, providing the structural architecture necessary to organize, deploy, and monitor digitized intellectual resources. In a fully realized ecosystem, the LMS is a dynamic platform that adapts to the interactions of its users, including students, instructors, and academic administrators.

Utilizing data analytics and artificial intelligence algorithms, the LMS tracks granular learning data. It records user engagement metrics, identifies specific anatomical modules where interaction time peaks, and flags formative assessments with high failure rates. Based on these datasets, the LMS can trigger automated, personalized pedagogical interventions, recommending supplementary learning materials tailored to an individual student's academic performance and cognitive needs. This data-driven personalization reduces the manual grading and administrative burdens traditionally placed on educators. By automating routine administrative tasks, the ecosystem frees substantial time for instructors, allowing them to focus their expertise on high-level pedagogical mentorship, specialized academic guidance, and the refinement of instructional design. Ultimately, the utility of the LMS extends beyond its underlying technology; it is determined by the quality of the digitized curriculum, the depth of content investment, and the strategic operational vision of the educational institution.

3.4 Strategic Directions for Institutional Expansion at UPES

The empirical deployment of the digital anatomy repository within the K20 Physical Education cohort serves as a scalable prototype for institution-wide digital transformation at UPES. The favorable evaluation outcomes—wherein 84.00% of participants reported high learning quality and 99.36% confirmed the responsiveness of the multimedia resources—provide an empirical justification for expanding this digital initiative. To leverage this momentum and achieve comprehensive pedagogical modernization, several strategic directions are proposed.

First, the institution should transition from utilizing disparate, module-specific cloud storage architectures toward a unified, institutional Learning Management System (LMS). While the cloud repository effectively resolved immediate accessibility challenges, a centralized LMS is required to operationalize the proposed four-layer ecosystem. The institutional LMS will serve as the operational core, integrating foundational content, immersive experiential tools, interactive social forums, and learning analytics into a cohesive digital environment. Expanding this model necessitates the systematic digitization of curricula across academic departments, prioritizing foundational and applied science modules that rely heavily on visual and spatial simulations, such as biomechanics, exercise physiology, sports medicine, and advanced kinesiology.

Furthermore, UPES should develop shared three-dimensional anatomical libraries and collaborative digital learning spaces. Because the implementation of immersive technologies involves substantial initial capital expenditures, fostering a culture of resource sharing—both internally among faculties and through inter-institutional partnerships with regional medical and sports universities—can optimize infrastructural investments. This collaborative approach mitigates redundant technological expenditures and positions the institution as a progressive model of digital pedagogical innovation within the regional higher education landscape.

Finally, the sustainable expansion of this digital ecosystem is contingent upon the continuous professional development of the academic faculty. The transition to a digital learning environment requires a shift in the instructional role, necessitating that faculty members evolve from traditional transmitters of knowledge to facilitators of asynchronous and synchronous digital experiences. Consequently, professional training initiatives must focus on mastering the technical operation of digital tools, designing higher-order formative and summative assessments, and curating interactive multimedia content. Enhancing the digital pedagogical competencies of the teaching staff represents a critical institutional investment. Through a synergistic integration of robust LMS infrastructure, immersive technologies, collaborative resource sharing, and digitally proficient educators, UPES can ensure the continuous delivery of equitable, high-quality, and competitive sports science education.

4. Conclusion

The contemporary era of digital transformation requires higher education institutions to fundamentally restructure their pedagogical frameworks, transitioning from static physical archives to dynamic, interactive digital learning ecosystems. This study successfully engineered and evaluated an online digital learning resource repository for the Anatomy module at UPES) The empirical findings validated the efficacy of this intervention: 84.00% of the respondents rated the learning quality as positive, 79.62% affirmed its high pedagogical and technological effectiveness, and 99.36% confirmed that the multimedia resources comprehensively satisfied their academic requirements.

Beyond resolving immediate infrastructural limitations, this initiative demonstrated that the systematic integration of digital lectures, academic references, and visual media enhanced student autonomy, facilitated student-centered models such as the flipped classroom, and established a continuous feedback mechanism for instructional calibration. Synthesized from these empirical insights, the study conceptualized a comprehensive Four-Layer Digital Learning Resource Ecosystem comprising foundational content, experiential tools, interactive environments, and administration and analysis. This framework suggested a scalable reference architecture for institutional upscaling.

For UPES and similar higher education institutions globally, the strategic imperative involves migrating toward unified Learning Management Systems that seamlessly integrate these four operational layers. Future institutional initiatives should be directed toward expanding this digital framework across diverse academic modules, integrating immersive technologies (VR/AR) to simulate complex biomechanical environments, and cultivating digital pedagogical competencies among faculty. Ultimately, establishing a sustainable, interconnected digital learning ecosystem optimizes institutional resources and ensures the continuous delivery of equitable, high-quality sports science education.

5. Acknowledgement

The author expresses profound gratitude to the Ho Chi Minh City University of Physical Education and Sports for institutional funding, administrative support, and facilitating the empirical implementation of this research initiative among the K20 undergraduate Physical Education cohort.

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