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A joint development of an e-learning management system with the IAEA: Transitioning from an on-premises hosting system to a cloud-based system

Hyeon-Jin Kim[1*], Kyoung-Pyo Kim[2], Ik Jeong[3]
[1,3]Nuclear Training and Education Center Korea Atomic Energy Research Institute, Daejeon, Republic of Korea; hj_kim@kaeri.re.kr (H.J.K.) ikjeong@kaeri.re.kr (I.K.)
[2]SMART Technology Development Division Korea Atomic Energy Research Institute, Daejeon, Republic of Korea; kpkim@kaeri.re.kr (K.P.K.)

Abstract: The establishment of a Learning Management System (LMS) is a critical foundation for effective teaching and learning in virtual environments, enabling active participation by educators and learners. This study investigates the transition from self-hosted to cloud-based LMSs, focusing on a collaborative project between the Korea Atomic Energy Research Institute (KAERI) and the International Atomic Energy Agency (IAEA) initiated in late 2010. Using a three-step Focus Group Interview (FGI) process involving six experts in e-learning and human resource development (HRD), the study identifies latent elements and evaluates factors based on the Content Validity Ratio (CVR). Key findings highlight scalability, cost-effectiveness, integration with current systems, support for a variety of learning formats, and improved collaboration and communication, with a particular emphasis on supporting varied learning modalities and cost efficiency. The results indicate that cloud-based LMSs provide significant cost advantages for public institutions and meet the diverse educational needs of students. Cost reduction and adaptability to global enterprise collaboration emerge as crucial considerations for LMS adoption in public-sector settings.

Keywords: *Collaborative development, E-learning; International atomic energy agency (IAEA), Learning management systems (LMS), Systematic approach to training (SAT).*

1. Introduction

Since the beginning of 2020, the educational sector has experienced extraordinary upheaval due to the COVID-19 pandemic [1]. Discussions about the necessity for instructors to use and adjust to e-learning systems, which had emerged from the past, could no longer be put off as traditional classroom classes were quickly moved online, leaving them to handle the task of creating and managing e-learning [2]. Numerous studies on the features, functions, and roles of online learning management systems (LMS) have been carried out in response to contemporary demands and the quick advancement of technology; however, the majority of LMS studies mostly concentrate on how to assist learners. The emphasis has been on [3], and by emphasizing learner interaction or usability, the primary features of the LMS have also been emphasized. Since instructors are the primary users and operators of LMS, it is vital to offer them practical assistance in creating instructional materials and managing learning procedures with LMS through LMS analysis from their point of view.

2. Review of Literature

2.1. The Development of Learning Management System Jointly Undertaken by the Korea Atomic Energy Research Institute and the International Atomic Energy Agency

In 2003, the International Atomic Energy Research Institute (IAEA) and the Korea Atomic Energy Research Institute (KAERI) launched the Asian Network for Education in Nuclear Technology (ANENT). Supported by the IAEA, the ANENT is a regional partnership aimed at managing nuclear science and technology knowledge, building human resources, and increasing capability. In order to

* Correspondence: hj_kim@kaeri.re.kr

keep a trained workforce in the region for sustainable nuclear technology and to help emerging nations launch their nuclear power programs, the ANENT seeks to promote, manage, and protect nuclear expertise.

The English-language ANENT Web Portal (WP) was the first resource and product. The KAERI created this site, including its concept and design, and members then assessed it. In April 2005, the KAERI took care of the WP's launch and continued functioning on their server at www.anent-iaea.org. The site facilitates communication both internally and externally by providing basic information about ANENT's administration and operations. Comprehensive details about ANENT's goals, members, organizational structure, and projects can be found in the 'About ANENT' and 'Activities' sections. Many helpful websites pertaining to nuclear research, technology, and information can be accessed through the 'Links' section. The 'Nuclear Education and Training (NET) Database,' which contains over 900 entries describing lectures and training programs offered at different universities, is accessible to registered members. Along with archival material, the 'Meetings and Events' section enumerates pertinent past, present, and projected future events.

The KAERI worked with the IAEA to design and build the 'Cyber Learning Platform (CLP).' To assist users in accessing a range of instructional resources and training course materials, the CLP was incorporated into the WordPress platform in August 2006. Four jobs are available to registered users who log in to the CLP: general manager, lecturer, learner, or course manager. Specific menus are available for each role based on its functions. With the help of the learning management system included in the CLP, teachers can register, enroll, track, and assess students' progress.

At the request of Member States in Asia and the Pacific, a four-year regional technical cooperation (TC) initiative called 'Supporting web-based nuclear education and training through regional networking (RAS/0/047)' was initiated in 2007. By utilizing the ANENT CLP to strengthen national and regional capacity-building initiatives, the project sought to address the increasing need for nuclear education and training opportunities, resources, and creative approaches. E-training, Train-the-Trainers programs that used the CLP as an e-learning tool, content development through expert missions, procurement initiatives, and fellowship programs were among its many operations. The project's beneficial effects on the development of their national human resources in nuclear science and applications were recognized by the participating Member States.

Over time, the significance of the CLP and e-learning activities became more widely acknowledged. But according to a SWOT analysis, a lot of users were worried about the deteriorating infrastructure of the CLP system. In response, the IAEA used the open-source MOODLE software to create a new LMS. Similar to the ANENT CLP, the LMS contains an automated system that enables teachers to enroll, monitor, and assess students' progress in each course. Users may now develop course content and browse the platform more easily thanks to the simplification of several elements. In December 2011, during the eighth ANENT Coordination Meeting, the LMS was set up at KAERI. While ANENT members function as Course Creators, in charge of registering students and creating courses, KAERI staff members manage registrations and monitor the system's overall operation as Site Administrators.

Similar regional educational networks were created in response to the successful results of ANENT. With assistance from the IAEA, these networks included the AFRA-Network for Education in Nuclear Science and Technology (AFRA-NEST) in Africa and the Latin American Network for Education in Nuclear Technology (LANENT) in Latin America and the Caribbean. These educational networks, particularly the European Nuclear Education Network Association (ENEN), have been actively collaborating with other national and regional educational networks worldwide. Periodically, the educational networks get together to identify and talk about shared needs, opportunities for collaboration, and potential solutions. In order to make its 'self-hosted to cloud-based LMS' accessible to the interested public at no cost, each network connected it with the IAEA Cyber Learning Platform for Network Education and Training (CLP4NET). This platform provides both instructor-led courses and self-paced e-learning resources.

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2.2. Factors to switch the LMS

Although there are numerous reasons to migrate to an LMS, numerous studies have identified the following crucial elements.

2.2.1. Scalability

Scalability is a crucial factor to take into account when selecting an LMS since it shows how well the platform can handle future increases in users, material, and features. The ability of an LMS to accommodate growing workloads, such as more instructors, students, courses, or interactive features, without compromising stability, speed, or performance is known as scalability [4]. Essentially, a scalable LMS is perfect for companies expecting long-term development or seasonal swings in usage since it can grow to meet institutional demands as they change or increase [5, 6].

Both vertical and horizontal scalability are possible with a highly scalable LMS. Increasing each server's capability to manage more data and traffic is known as vertical scalability. By adding more servers to the system, horizontal scalability, on the other hand, enables the platform to support a larger user base without compromising performance [7]. For educational institutions that might need to quickly scale their LMS during enrollment spikes or when launching new programs, this flexibility is crucial [8].

Additionally, a scalable LMS facilitates versatility, allowing organizations to include third-party tools, expand functionalities, or introduce unique features with no interference to the main system [9]. Because it eliminates the need for total redesigns when demands change, this flexibility not only future-proofs the LMS but also saves long-term operating expenses. Recent studies show that, by preserving system performance and dependability even when the number of users rises, LMS platforms with good scalability frequently earn higher user satisfaction [10].

As a result, scalability guarantees that an LMS may expand to meet the changing needs of the organization, creating a flexible and long-lasting learning environment for teachers, administrators, and students.

2.2.2. Cost-Effectiveness

Cost-effectiveness is a crucial consideration when choosing a LMS, since it assesses if the platform's costs are reasonable given the value it provides. Both upfront and recurring expenses, such as software licensing, implementation, customization, training, and continuing maintenance, are taken into account when determining cost-effectiveness [11]. If an LMS fulfills or surpasses operational and educational goals without placing an undue financial burden on institutions, it is cost-effective and allows them to optimize their budgetary influence on education [5, 6].

An affordable LMS strikes a compromise between cost and capability by providing necessary features including analytics, content distribution, user administration, and assessment tools. Additionally, it takes scalability into account, making sure the platform can expand with the organization without requiring expensive upgrades. Because they transfer some of these costs to outside providers and limit infrastructure expenditures and maintenance duties, cloud-based or open-source LMS platforms are frequently cited as cost-effective choices [12].

Cost-effectiveness also takes into account hidden expenses such technical support, integration with other learning resources, and any possible outage that can interfere with instruction and need costly debugging [13]. Institutions can choose an LMS that offers a sustainable return on investment and gain a better understanding of the long-term financial implications of the system by assessing total cost of ownership (TCO). To ensure that institutions only pay for what they use, cost-effectiveness also entails having the flexibility to add or remove functions as needs change [14]. Thus, an LMS that supports a high-quality learning experience without needless financial stress is one that is in line with both financial limitations and educational objectives.

2.2.3. Flexibility and accessibility

When choosing a LMS, 'flexibility and accessibility' are important considerations that have a big impact on how well instruction is delivered. The term 'flexibility' describes the LMS's capacity to

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support different pedagogical approaches, course formats, and learning styles, enabling teachers to modify assessments and content to suit a range of student demands [15]. Features that allow educators to construct a more effective and interesting learning environment include adjustable course design, a variety of assessment techniques, and integration with various instructional resources [16].

Contrarily, accessibility refers to the system's capacity to offer all students fair access, irrespective of their location, gadgets, or unique requirements. A more inclusive learning environment is promoted by an accessible learning management system, which guarantees that students can engage in their classes at any time and from any location [17]. This involves conforming to accessibility guidelines, which provide accommodations for students with disabilities, and being compatible with a variety of platforms, including computers, tablets, and smartphones [18].

Additionally, synchronous and asynchronous learning can be supported by an adaptable and user-friendly LMS, giving students the option to participate in conversations in real time or view recorded materials whenever it is most convenient for them. By accommodating different schedules and time zones, this duality not only improves student engagement but also raises enrollment and retention rates [19]. In the end, incorporating accessibility and flexibility into an LMS not only improves the educational process but also supports equal chances for all students and lifelong learning, which are values of modern education.

2.2.4. Improved Tracking and Reporting

Improved tracking and reporting is a crucial consideration when choosing an LMS, as it greatly improves the administration of learning procedures and results. This aspect speaks to the system's capacity to efficiently track student development, involvement, and performance. Better tracking enables teachers to collect data on student actions in real time, including assessment results, time spent on assignments, and course completion rates [20]. By identifying at-risk kids and offering prompt interventions, these insights help teachers create a more individualized learning environment [15].

Furthermore, strong reporting features enable administrators to assess the efficacy of instructional tactics and course content as well as analyze trends. Teachers can make well-informed decisions that promote ongoing teaching and learning development by creating thorough reports on student achievement, course efficacy, and engagement measures [21]. These reports can also show adherence to institutional and regulatory norms and support accreditation procedures [16].

The usability of tracking features is further improved by the ability to visualize data through dashboards and analytics, which makes it simple for stakeholders to understand complex information [22]. This feature encourages accountability and openness in educational institutions while also streamlining administrative duties. Thus, better tracking and reporting in an LMS contributes to higher educational quality and student retention rates by supporting both individual student achievement and more general institutional objectives.

2.2.5. User Engagement and Interactivity

User engagement and interactivity are important considerations when choosing an LMS, as they have a big impact on how well online learning experiences work. Interactivity is the system's capacity to support dynamic interactions between students, teachers, and content, whereas user engagement is the degree to which students actively participate in the educational process [23]. To encourage active learning and maintain student motivation, a highly engaging learning management system (LMS) uses a variety of interactive components, including discussion boards, tests, multimedia content, and collaborative tools [24].

By enabling students to interact with the content in meaningful ways and promoting inquiry and critical thinking, interactivity improves the learning process [25]. Peer-to-peer collaboration and real-time assessment feedback, for example, can improve social learning and create a feeling of community [26]. Additionally, gamification features like leaderboards, interactive scenarios, and medals might boost students' enthusiasm and dedication to their studies [27].

In addition to increasing information retention, an LMS that places a strong priority on user involvement and interactivity also raises completion rates and boosts student happiness in general [28].

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Educational institutions can produce a more effective learning experience that is in line with modern pedagogical techniques by cultivating an atmosphere where students feel engaged and connected. To maximize an LMS's potential and serve a variety of learning objectives, user engagement and interaction are ultimately essential.

2.2.6. Integration with existing systems

When it comes to choosing an LMS, *integration with existing systems* is a critical component that impacts how well an institution's educational technology ecosystem works. According to Davis (2017), this integration involves the LMS's capacity to easily interface with other programs and systems that are currently in use, including content management systems (CMS), student information systems (SIS), and other teaching resources [20]. According to Wang (2018), efficient integration reduces the need for redundant data entry, expedites administrative procedures, and improves the user experience for both teachers and students [29].

The ability to integrate enables organizations to make the most of their current resources while guaranteeing seamless data transfer between systems. Functionalities like enrollment management, reporting, and analytics can be improved by this interconnection, which will ultimately result in better decision-making [30]. An LMS that is coupled with a SIS, for example, can immediately update student grades and enrollment statuses, minimizing errors and administrative hassles [17].

Additionally, a well-integrated LMS can make it easier for students to use outside tools and resources, increasing the variety of learning possibilities they have access to. Access to outside content repositories, evaluation systems, and communication tools that enhance the educational process are all included in this [26]. As a result, selecting an LMS with strong integration features is crucial to developing a unified learning environment that raises teaching efficacy and boosts student results.

2.2.7. Support for Diverse Learning Formats

Support for diverse learning formats is a crucial consideration when choosing an LMS since it improves the flexibility and efficiency of instruction. This idea relates to the LMS's capacity to support a range of teaching strategies and content kinds, such as competency-based education, blended learning, and synchronous and asynchronous learning [26]. In order to accommodate various learning preferences and styles, a good LMS should support multimedia content, including reading materials, interactive simulations, and videos [31].

By supporting a variety of learning formats, teachers can create classes that cater to the requirements of a wide range of students, increasing student engagement and enhancing learning results [5, 6]. For example, learners who need varying degrees of structure and engagement can benefit from flexibility offered by an LMS that supports both live virtual classrooms and self-paced modules [32]. Furthermore, incorporating assessment tools that accommodate several formats—such as conversations, quizzes, and project submissions—improves the capacity to gauge students' comprehension and development in a thorough manner.

Furthermore, the ability to provide a variety of learning formats is becoming more and more crucial as educational paradigms move toward individualized learning. This adaptability helps teachers use creative teaching techniques in addition to meeting the needs of students with varying learning speeds [15]. In the end, developing an inclusive, productive learning environment that promotes student success across a variety of settings and needs requires an LMS that supports a variety of learning modalities.

2.2.8. Enhanced Collaboration and Communication

Enhanced collaboration and communication is a crucial component that has a big impact on the learning process when choosing an LMS. In order to provide a collaborative learning environment, this idea relates to the LMS's capacity to enable meaningful interactions between students, teachers, and course materials [33]. Discussion boards, group projects, and real-time messaging are examples of enhanced collaboration features that allow students to actively interact with their teachers and peers, encouraging knowledge exchange and community development [34].

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Announcements, email, and integrated video conferencing are examples of effective communication options in an LMS that guarantee seamless information exchange amongst all parties involved. Students can work together regardless of their schedules or geographical locations because to this connectivity, which is essential for synchronous and asynchronous learning activities [35]. For example, students are more motivated and engaged when they can join in online study groups or receive immediate feedback via chat [28].

Additionally, better academic achievement and retention rates might result from an LMS that places a high priority on greater cooperation and communication. According to research, students who participate in cooperative learning activities are more likely to experience a sense of support and belonging, which can enhance their entire educational experience [36]. In the end, developing a dynamic and inclusive learning environment that satisfies the various demands of today's students requires an LMS that promotes improved cooperation and communications.

3. Methodology

3.1. Data Collection

This study aims to shed light on the effects of switching from self-hosted to cloud-based LMS, with a particular emphasis on the joint development of an LMS to improve e-learning that the KAERI and the IAEA have been working on since late 2010. To achieve the goal of this study, a total of six specialists in the domains of e-learning and human resource development (HRD) participated. Due to the small number of specialists, this study's methodology leaned more toward qualitative than quantitative activities, with a particular emphasis on Focus Group Interviews (FII). According to Creswell (2014) and Patton (2015), FII is characterized by the following: an in-depth investigation of obtaining detailed information from a single person at a time; an individual perspective to obtain a unique insight into how that particular individual sees the world and interacts with a particular topic or situation; and open-ended questions that generally encourage participants to share their thoughts freely rather than giving succinct, yes/no answers [37, 38].

3.2. Measures

From November 2–6, 2014, the interviewer for this study, who was limited to one HRD specialist, spoke with each expert one day. 'What are the factors to the transition from self-hosted to cloud-based LMS, featuring e-learning jointly undertaken by the KAERI and the IAEA since late 2010?' was the question posed to each interviewee. At the same time, the interviewer gave information about the combined e-learning and LMS project that the two institutions were working on. In the first interview, a total of eight elements were presented.

The second interview was conducted three weeks after the first, from November 25 to 28, with only one interviewer each day. In order to illustrate the eight elements that were extracted from the initial interview, each participant was asked, 'What are the main factors to the transition from self-hosted to cloud-based LMS?' In the first interview, a total of eight elements were presented. The five factors—scalability, cost-effectiveness, interaction with current systems, support for a variety of learning formats, and improved cooperation and communication—were thus discussed in the second interview.

3.3. Analysis

Three steps are included in the analysis. First, the interviewers focused on e-learning that has been collaboratively conducted by the KAERI and the IAEA since late 2010 and identified the latent five elements out of the eight criteria to swift from self-hosted to cloud-based LMS. Second, using a five-point Likert-type scale (1 being not important, 2 being somewhat important, 3 being quite important, 4 being quite a lot important, and 5 being a great amount important), each interviewee concurrently assessed the five factors. Thirdly, content validity was put into practice. According to Lawshe (1975), it is examined using the Content Validity Ratio (CVR) [39]. The number of panelists determines the CVR's minimum value; if the value is higher than this, the question is deemed to have content validity. The table below displays the minimal CVR values.

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Table 1.
Minimum values of the number of panelists on content validity ratio.

Number of panelists	Minimum value
5	0.99
6	0.99
7	0.99
8	0.75
9	0.78
10	0.62
11	0.59
12	0.56
13	0.54
14	0.51
15	0.49
20	0.42
25	0.37
30	0.33
35	0.31
40	0.29

4. Result and Discussion

The respondents perceived the five factor as 'quite a lot important' or 'a great amount important' (M > 4.0). The highest mean was for 'support for diverse learning formats' (M = 4.83), and the lowest means was for 'scalability' (M = 4.17). All other means was between the two ($4.17 < M_{\text{cost-effectiveness}}$, $M_{\text{integration with existing systems}}$ and $M_{\text{enhanced collaboration and communication}} < 4.83$). However, the mean of other factors except the five factor was below four ($M_{\text{Flexibility and Accessibility}}$ and $M_{\text{Improved Tracking and Reporting}}$, and $M_{\text{User Engagement and Interactivity}} < 4.0$). The table 2 showed the detail scores by the six experts.

Table 2.
Score results by Experts.

	F_1 [a]	F_2 [b]	F_3 [c]	F_4 [d]	F_5 [e]
E_1	4	4	4	5	4
E_2	4	5	5	5	5
E_3	4	4	4	5	4
E_4	4	5	5	5	4
E_5	4	4	4	5	4
E_6	5	5	4	4	5
Average	4.17	4.50	4.33	4.83	4.33

Note: a. scalability, b: cost-effectiveness, c: integration with existing systems, d: support for diverse learning formats, e: enhanced collaboration and communication.

The following is how the study's findings are directly related to the conversation. First, the key elements for moving from self-hosted to cloud-based LMS for the joint e-learning activities conducted by the KAERI and the IAEA are scalability, cost-effectiveness, integration with current systems, support for a variety of learning formats, and improved collaboration and communication. The other two elements—the enhanced tracking and reporting and the flexibility and accessibility—are far from the transit between the two. The former is the LMS's capacity to support different pedagogical approaches, course formats, and learning styles, which enables teachers to modify assessments and content to suit a range of student demands [15]. The latter is the system's capacity to efficiently track student performance, engagement, and advancement. It is probable that the ANENT e-learning practitioners will run e-learning programs on the IAEA-regulated structured-learning platform. This

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demonstrates that accessibility and flexibility might not be the most important aspects when switching between the two.

Second, the most important consideration when switching from a self-hosted to a cloud-based learning management system is 'support for diverse learning formats.' The LMS's capacity to support a range of instructional approaches and content kinds, such as competency-based education, blended learning, and synchronous and asynchronous learning, is intimately related to its support for multiple learning formats [26]. The IAEA oversees the ANENT e-learnings LMS, which is a structured-learning platform that makes it challenging to advance or implement the extensive range of learning activities, including supporting different learning styles, course designs, and pedagogical approaches. In contrast to scalability, it might be relatively simple to implement or advance in order to accommodate different kinds of content and teaching methods [31].

Third, the transition from self-hosted to cloud-based LMS also depends on other considerations, including as cost-effectiveness, integration with current systems, and improved cooperation and communication. The cost savings is closely related to the three previously mentioned reasons. Cost-effectiveness dictates that the limited source and cost should demonstrate the greatest effectiveness. When compared to buying new systems or adding features or applications to existing ones, integration with existing systems is closely linked to cost savings. Compared to weak ties and ineffective communication, improved collaboration and communication may help save time and money [40].

5. Conclusion and Limitation

This study aims to investigate the effects of switching from self-hosted to cloud-based LMS, with a particular emphasis on the cooperative creation of an LMS to improve e-learning. The goal of the joint effort between the KAERI and the IAEA was driven by the emphasis on the group development of LMS. The results showed that the complex interaction of individual and environmental factors—such as scalability, cost-effectiveness, integration with existing systems, support for diverse learning formats, and enhanced collaboration and communication—is the most important factor influencing LMS conversion. The following is the study's conclusion.

First, when compared to self-hosted LMS, cloud-based LMS offers public institutions significant cost savings. Cloud-based LMS functions on remote servers managed by the provider, eliminating the need for upfront infrastructure costs, in contrast to self-hosted systems that requires costly on-site servers, frequent maintenance, and a dedicated IT staff. Furthermore, cloud-based LMS enables organizations to pay on a subscription basis, increasing or decreasing in accordance with usage requirements. This is very advantageous for effectively managing budgets. The resources that institutions must set aside for continuing support are further reduced by the automated updates and security features offered by cloud LMS providers. As a result, cloud-based LMS becomes a more economical option for government organizations looking to efficiently use their limited resources.

Second, when choosing an LMS for public institutions, support for a variety of learning modalities is essential to meeting the unique demands of students. To accommodate various learning styles and skill levels, a strong LMS should support interactive simulations, multimedia content, real-time virtual courses, and classic text-based lectures. An inclusive learning environment that accommodates both visual and auditory learners as well as those who can benefit from interactive, hands-on experiences is made possible by this flexibility. Additionally, a broad content strategy makes it possible for public institutions to facilitate remote and hybrid learning, guaranteeing accessible for students in any situation or place. Thus, giving priority to an LMS that accommodates various learning formats improves educational efficacy and accessibility, making it crucial for public institutions.

Third, when choosing an LMS in collaboration with global enterprises, cost reduction is a crucial consideration. Managing scarce resources across several nations with different financial restrictions is a common task for collaboration. Institutions can devote more dollars to critical program requirements like curriculum development, language translation, and local support services that improve the learning experience by selecting an inexpensive LMS. Scalability is another feature of an affordable LMS that lets the organization reach a larger audience without going over budget. Furthermore, choosing an affordable LMS with strong functionality encourages sustainability over the long run, guaranteeing the

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survival of global educational collaborations. Therefore, cutting expenses when choosing an LMS directly contributes to the sustainability and scope of international educational projects.

Despite the following significant findings, this study has many limitations. First, the lack of adequate expert participants limited the diversity of insights and decreased the generalizability of findings, hence limiting the validity and reliability of this study. Maxwell (2013) highlights that a broad participant pool improves validity in qualitative research [41], whereas Creswell (2014) asserts that a larger, more representative sample is essential for establishing reliability [37]. Yin (2018) goes on to say that increasing the number of experts can enhance data saturation and increase the conclusions' resilience [42]. Therefore, to support the study's findings and applicability, more expert participants are required in follow-up research.

Second, due to its exclusive focus on a single project, this study's trustworthiness was constrained, which also limited the scope of its conclusions and their generalizability. According to Yin (2018), broadening the research's focus to encompass several distinct initiatives can improve the dependability of findings by offering a more comprehensive context for the data [42]. Furthermore, Maxwell (2013) contends that examining a variety of cases strengthens conclusions and makes them applicable to a larger range of situations [41]. Therefore, a more varied project sampling should be the top priority for future study in order to improve both application and reliability.

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