

Identifying Influencing Factors of E-Learning Success: A DEMATEL Approach

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Article information	Abstract
<p>Key words</p> <p>E-learning; Critical Success Factors (CSFs); DEMATEL</p> <p>Received 22 04 2026, Accepted 04 05 2026, Available online 05 05 2026</p>	<p>The rapid expansion of E-learning in higher education has transformed the way teaching and learning processes are delivered through digital platforms. This study examines the relationships among critical success factors that influence the effectiveness of E-learning systems. The Decision-Making Trial and Evaluation Laboratory (DEMATEL) method was employed to identify and analyze the causal relationships among the main dimensions of E-learning. Five key dimensions were considered: students, instructors, design and content, system and technological infrastructure, and institutional management. Expert evaluations were used to investigate the direct, indirect, and interdependent relationships among these dimensions. The results revealed several important associations among the E-learning success factors. The design and content dimension was identified as the most influential factor affecting the E-learning environment, followed by the system and technological dimension and institutional management. In contrast, the instructors' and students' dimensions were found to be primarily influenced by other factors within the system. The cause-effect relationships among the dimensions were identified, and directions for improving E-learning implementation were discussed. The findings provide useful insights for higher education institutions to enhance the effectiveness of E-learning systems by prioritizing improvements in instructional design and technological infrastructure.</p>

1. Introduction

The learning context in higher education is experiencing a radical transformation, with Online or Remote learning emerging as one of the most significant changes in the educational system. Remote learning, or e-learning, is going through rapid growth and is increasingly favored over conventional learning and teaching methods, supported by advances in computer-based technologies that have made information exchange easier, quicker, more transparent, and effective [1].

It relies on electronic devices to deliver content via different electronic media, including the Internet, audio, video, satellite broadcasts, interactive television, and CD-ROM [2], covering a wide range of applications and methods that use accessible digital media and resources for education and training [3]. It enables learning processes to occur without the need for face-to-face physical meetings at the same location and time, serving as an electronic service independent of time and location [4, 1]. This change has been driven by the rapid growth of Internet connectivity and digital technologies, encouraging higher education institutions worldwide to transition to digital education. [3, 4]. Universities have increasingly adopted remote learning as a modern approach to teaching, that helps reduce classroom restrictions and offers students more opportunities for communication and interaction, leading to more effective learning [3]. The COVID-19 global pandemic significantly accelerated this adoption, as governments closed direct access to education and higher education institutions were forced to offer online lectures, prompting students and professors to work and study from home [3, 4].

Students can learn independently through modern technologies, free from traditional teaching constraints such as direct supervision and rigid control, and with flexibility in terms of time and location. [1]. Remote learning can significantly impact students' academic achievements, performance, and positive experience, often surpassing normal classroom education [3]. The fast development in information technology, software, and high-configuration hardware make remote learning more user-friendly and useful, thereby improving learning outcomes at universities [1]. The electronic format of course materials makes it easier to store and retain important information over time, while also improving the efficiency of accessing and managing educational content. [2]. Remote learning is recognized for its useful, flexible, and cost-effective characteristics, offering improved opportunities for information sharing, cost efficiency, and greater accessibility through the World Wide Web. [3, 1]. For institutions, adopting remote learning enables them to adapt to changing conditions, maintain the continuity and quality of education, respond to the growing demand for flexible learning from distance students and working professionals, and reduce operational costs. [2, 3, 4, 1].

However, despite these advantages, remote learning also presents considerable challenges that must be addressed to ensure its effectiveness. Despite significant investments in remote learning systems, their usage can remain low, and the full and successful implementation of remote learning is also a challenge for some universities [1]. Developing, managing, and continuously improving E- learning systems presents significant challenges for educational institutions [2]. The effectiveness of remote learning systems heavily relies on students' adoption and requires significant human investment in training, as innovative technologies alone may not produce the desired academic changes [3]. Students may struggle to adapt to online platforms because of limited internet access or a lack of essential resources, while high data costs and social inequalities further increase the gap in access to Remote education. [3]. The success of remote learning depends on multiple Critical Success Factors (CSFs) defined as the essential elements or activities required for an organization or project to achieve its mission and ensure success [4]. Critical success factors from different dimensions can have diverse impacts on the remote learning system, requiring careful analysis to ensure effectiveness [1]. These factors include perceived quality, which encompasses information quality, system quality, and service quality [4]; robust information technology infrastructure

[4]; instructor quality and communication ability [2]; student attitudes, motivation, and self-efficacy [1]; course design and content clarity [1]; organizational support [4]; and task-technology fit [3]. As Eccles (1991) noted, "What gets measured gets attention" [2], emphasizing that comprehensive assessment frameworks and the strategic prioritization of critical success factors are essential for the continuous improvement and long-term success of remote learning in higher education.

2. Literature review

The transition toward a knowledge-based economy has significantly reshaped educational paradigms, emphasizing the critical role of information and communication technology (ICT) in enabling knowledge creation, dissemination, and application. As highlighted by Masoumi (2006), ICT serves as a fundamental enabler of this transformation, influencing how individuals learn, interact, and acquire knowledge in modern societies. Within this context, E-learning has emerged as a key educational approach, necessitating a deeper understanding of the factors that contribute to its effectiveness and sustainability [5].

Early empirical studies have primarily focused on users' perceptions and attitudes toward E-learning systems. For instance, Liaw et al. (2007) investigated both instructors' and students' perceptions, revealing generally positive attitudes toward E-learning as an effective instructional tool [6]. Similarly, Shi Yong-gui et al. (2007) conducted a comparative analysis between Mainland China and Taiwan, demonstrating that cultural differences significantly influence learner satisfaction and overall system success, thereby highlighting the contextual nature of E-learning adoption [7].

A more structured approach to identifying critical success factors (CSFs) was introduced by Selim (2007), who categorized E-learning determinants into four main dimensions: instructor, student, information technology, and institutional support. Using confirmatory factor analysis, the study identified key variables influencing system acceptance and effectiveness in higher education contexts [8]. Expanding on this multidimensional perspective, Sun et al. (2008) proposed an integrated model incorporating six dimensions, including learner characteristics, instructor attributes, course design, technology, and environmental factors. Their findings emphasized that variables such as learner computer anxiety, instructor attitudes, course flexibility, and perceived usefulness significantly impact learner satisfaction [9].

Further qualitative insights were provided by Menchaca and Bekele (2008), who highlighted the importance of flexibility, collaboration, and community building in online learning environments. Their findings underscore the necessity of aligning technological tools with diverse learning styles while ensuring active participation and institutional support [10]. In parallel, Ozkan and Koseler (2009) proposed the Hexagonal E-Learning Assessment Model (HELAM), which offers a comprehensive framework for evaluating learning management systems across multiple dimensions, including system quality, service quality, and stakeholder perspectives [2].

Subsequent studies have reinforced the importance of identifying and evaluating CSFs for successful E-learning implementation. Mosakhani (2010) emphasized that understanding these factors enables institutions to overcome implementation challenges and enhance system

performance [11]. Similarly, Malik (2010) demonstrated that student satisfaction is influenced by a combination of learner-related, instructor-related, design-related, course-related, and technical factors, indicating the multifaceted nature of E-learning success [12].

In developing country contexts, Bhuasiri et al. (2012) identified key determinants such as curriculum design, technological awareness, and learner motivation, highlighting the importance of contextual factors in shaping E-learning adoption [13]. FitzPatrick (2012) further contributed by proposing a Key Success Factors (KSF) model aimed at guiding E-learning implementation in secondary education, emphasizing strategic planning and policy support [14]. Likewise, Frimpon (2012) categorized 17 CSFs into four primary roles—student, instructor, technology, and institution—providing a structured framework for understanding E-learning complexity [15].

More recent studies have integrated theoretical models such as the Technology Acceptance Model (TAM) and Information Systems (IS) success frameworks to explain E-learning adoption. Kanwal and Rehman (2017) extended TAM by incorporating external variables, demonstrating that factors such as computer self-efficacy, internet experience, and system characteristics significantly influence perceived ease of use and usefulness [16]. Alhabeeb and Rowley (2018) further examined differences between students' and instructors' perspectives, highlighting variations in perceived success factors across stakeholder groups [17].

In addition, Cidral et al. (2018) developed and empirically validated a comprehensive model linking system usage, satisfaction, and individual impact, thereby providing a holistic understanding of E-learning effectiveness [18]. Building on this, Al-Fraihat et al. (2020) proposed an integrated model demonstrating that E-learning success is significantly influenced by system quality, information quality, service quality, learner characteristics, and instructor attributes. Their findings confirm the interdependent nature of these factors in determining user satisfaction and perceived usefulness [19].

Recent advancements have also focused on multi-criteria decision-making (MCDM) approaches to evaluate E-learning systems. Naveed et al. (2020) employed such methods to systematically identify and prioritize CSFs, emphasizing the importance of considering multiple criteria in evaluating system performance [1]. Similarly, Nalintippayawong et al. (2023) utilized structural equation modeling to analyze E-learning success in mandatory usage contexts, providing insights into user behavior and system effectiveness [20]. Furthermore, Naveed et al. (2023) explored sustainable cloud-based mobile learning environments, reflecting the ongoing shift toward more flexible and scalable digital learning solutions [21].

Collectively, these studies demonstrate that E-learning success is determined by a complex interplay of factors spanning system quality, learner characteristics, instructor roles, institutional support, and technological infrastructure. Moreover, learner satisfaction and system acceptance are influenced by psychological, technical, and cultural dimensions, underscoring the need for context-sensitive evaluation models. This is particularly critical in the context of Libyan universities, where challenges such as limited ICT infrastructure, inconsistent internet connectivity, and evolving institutional readiness significantly shape the

effectiveness of E-learning systems. The increasing integration of mobile and cloud-based technologies further highlights the dynamic evolution of E-learning environments. Therefore, a comprehensive analytical approach that captures the interrelationships among these factors is essential for enhancing system effectiveness in Libyan universities. This study addresses this need by employing the DEMATEL method to identify and analyze the causal relationships among critical success factors, thereby providing deeper insights for improving E-learning implementation and sustainability in the Libyan higher education

2.1 Students' dimension

The students' dimension refers to the learner-related factors associated with participation in E-learning environments. It includes elements such as motivation, willingness to engage, ICT self-efficacy, interaction with peers, and commitment to online learning. These factors reflect students' readiness and engagement in using E-learning systems and their ability to effectively interact with digital learning resources.

2.2 Instructors' dimension

The instructors' dimension refers to the teaching-related factors associated with the delivery and facilitation of E-learning. It includes instructors' attitudes toward E-learning, ICT competencies, communication skills, feedback practices, and interaction with students. This dimension reflects the instructional practices and teaching capabilities involved in online learning environments.

2.3 Design and contents' dimension

The design and contents' dimension refers to the characteristics of learning materials and course structure in E-learning environments. It includes course organization, content clarity, interactivity, multimedia integration, and instructional design quality. This dimension reflects how educational content is structured and presented to support the learning process.

2.4 System and technological dimension

The system and technological dimension refer to the technical characteristics of the E-learning platform and its supporting infrastructure. It includes system accessibility, reliability, technical support, internet connectivity, and platform usability. This dimension reflects the technological environment through which E-learning activities are delivered and managed.

2.5 Institutional management dimension

The institutional management dimension refers to the organizational and administrative aspects related to E-learning implementation. It includes management support, training provision, infrastructure readiness, financial resources, and policy considerations. This dimension reflects the institutional arrangements and support mechanisms associated with E-learning systems.

3. Method

This study investigated the relationships between key E-learning dimensions, namely the student dimension (F1), the instructor dimension (F2), the design and content dimension (F3), the system and technology dimension (F4), and the institutional management dimension (F5).

3.1 Sample and procedure

In this study, the critical success factors of E-learning identified from previous literature were utilized to develop a structured questionnaire. A convenience sampling approach was employed to select lecturers' and postgraduate students from different Libyan Universities. Sixty invitation emails were sent individually to participants who had prior experience with E-learning systems. After three follow-up attempts, 41 participants (34 males and 7 females) agreed to take part in the study.

Table 1 presents the key demographic characteristics of the respondents. Regarding age distribution, 3 participants were between 25–30 years, 5 were aged 31–40 years, 6 were between 41–50 years, and 7 were over 50 years old. Most respondents (n = 20) were enrolled in master's programs, 19 were holding PhD degrees, and only 2 were registered in bachelor's programs.

Table 1 Sample characteristics (n:41).

Characteristics	n (%)
Gender:	
Male	34 (82.9%)
Female	7 (17.1%)
Age:	
25 - 30	3 (7.3%)
31 - 40	5 (12.5%)
41 - 50	26 (63.4%)
>50	7 (17.1)
Education level	
Bachelor	2 (4.9%)
Master	20 (48.8%)
PhD	19 (46.3%)

A structured questionnaire was sent to the respondents via Google Forms, along with detailed instructions explaining how to evaluate the degree to which each factor influences the others. Each factor was clearly defined, and an example was included to illustrate its relevance within the framework of this study.

Respondents were requested to assess the weight or magnitude of influence that each factor exerts on the remaining factors (see Table 2) shows an illustrative templet on how the pairwise matrix should filled where (F1-F2) indicate the influence factor (F1) has on factor (F2). A five-point rating scale was employed: 0 (no influence), 1 (low influence), 2 (moderate influence), 3 (high influence), and 4 (very high influence). The collected responses were coded individually to construct the cause–effect relationship diagram, after which the normalization process was carried out. The detailed procedures for developing the cause–effect map are presented in the following subsection.

Table 2 The proposed pairwise relationships.

Factors	F1	F2	F3	F4	F5
F1	0	F1-F2	F1-F3	F1-F4	F1-F5
F2	F2-F1	0	F2-F3	F2-F4	F2-F5
F3	F3-F1	F3-F2	0	F3_F4	F3-F5
F4	F4-F1	F4-F2	F4-F3	0	F4-F5
F5	F5-F1	F5-F2	F5-F3	F5-F4	0

Instructions for filling out the matrix: 0 = No influence; 1 = Low influence; 2 = Medium influence; 3 = High influence; and 4 = Very high influence.

F1-F2: The influence level factor1 has on factor2.

3.2 DEMATEL method

The Decision-Making Trial and Evaluation Laboratory (DEMATEL) method was initially developed by the Battelle Memorial Association in Geneva. It has since been widely recognized as an effective technique for analyzing and resolving cause–effect relationships among evaluation criteria [22][23][30][24]. DEMATEL is particularly suitable for examining complex interrelationships and interdependencies, as it is not constrained by sample size limitations [25].

The method has been extensively applied across various domains, including the identification of critical factors [26][27] [28], supply chain management [29], service management [30] [31], and failure mode and effects analysis (FMEA) [32] [33]. Furthermore, DEMATEL has been integrated with set theory to address complex decision-making problems characterized by uncertainty and ambiguity [34] [35] [36].

The DEMATEL approach involves several systematic steps to obtain the final results, which are outlined in figure 1.

E-learning Critical Success Factors Evaluation Using DEMATEL

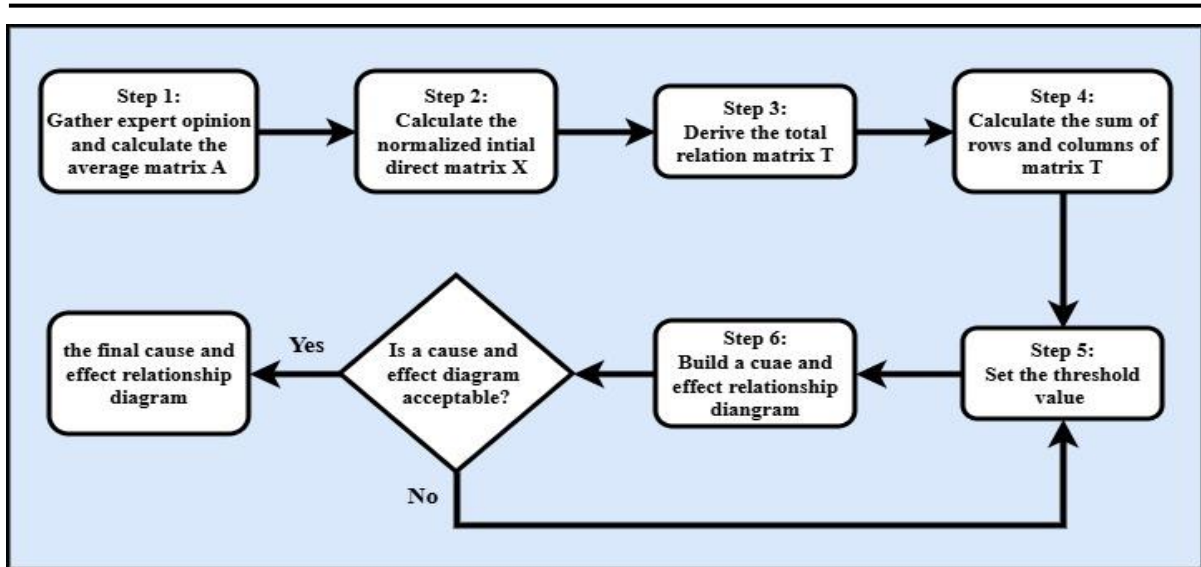


Figure 1: DEMATEL steps

Table 3. Factors influencing E-learning

Factors	Description
F1	Students' Dimension
F2	Instructors' Dimension
F3	Design and Contents' Dimension
F4	System and Technological Dimension
F5	Institutional Management Dimension

Step 1. Calculating direct relation matrix A

After gathering the evaluations from the decision-makers regarding the relationships among the variables (see Table 4), the direct-relation matrix is constructed. This matrix represents the degree of influence that element i (located in the row) exerts on element j (located in the column). Each entry a_{ij} indicates the influence that the element i have on the element j .

Table 4: Scores of the relations

Type of relations between variables	Influence score
No influence	0
Low influence	1
Medium influence	2
High influence	3
Very high influence	4

The $n * n$ matrix A is found by averaging all experts' scores.

$$A = \begin{bmatrix} a_{11} & \cdots & a_{1j} & \cdots & a_{1n} \\ \vdots & \ddots & \vdots & \ddots & \vdots \\ a_{i1} & \cdots & a_{ij} & \cdots & a_{in} \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ a_{n1} & \cdots & a_{nj} & \cdots & a_{nn} \end{bmatrix} \quad (1)$$

$$a_{ij} = \frac{1}{H} \sum_{k=1}^H x_{ij}^k \quad (2)$$

Where H is the number of experts.

Step 2. Normalizing the direct-relation matrix

On the base of the direct-relation matrix A , the normalized direct-relation matrix X can be obtained by the following formulas:

$$\text{Let } s = \max(\max_{1 \leq i \leq n} \sum_{j=1}^n a_{ij}, \max_{1 \leq j \leq n} \sum_{i=1}^n a_{ij}) \quad (3)$$

Where S is the maximum value between the summation of rows and columns in the direct matrix A .

$$\text{Then the nomalized matrix } X = \frac{A}{S} \quad (4)$$

Step 3. Attaining the total-relation matrix T .

Once the normalized direct-relation X is obtained, the total-relation matrix T can be calculated by applying the following formula, (5), in which I is denoted as the identity matrix.

$$T = X(I - X)^{-1} \quad (5)$$

Step 4. Producing a causal diagram.

The sums of the rows and columns are denoted by vectors \mathbf{R} and \mathbf{C} , respectively. A causal diagram is then generated by plotting $(R + C)$ on the horizontal axis and $(R - C)$ on the vertical axis. This graphical representation facilitates the analysis of relationships among the factors and helps identify the most significant and influential ones (see Figure 2). A higher value of $(R + C)$ indicates a greater level of importance of the corresponding factor within the decision-making process.

Conversely, the value of $(R - C)$ reflects the overall nature of each variable [37]. A positive $(R - C)$ value suggests that the factor predominantly influences others, whereas a negative value indicates that it is mainly influenced by other factors. Furthermore, the position of each factor on the cause–effect scatter plot can be used to determine whether it functions primarily as a cause or as an effect [38].

$$R = [r_i]_{n \times 1} = \left[\sum_{j=1}^n t_{ij} \right]_{n \times 1} \quad (6)$$

$$C = [c_i]_{1 \times n} = \left[\sum_{i=1}^n t_{ij} \right]_{1 \times n} \quad (7)$$

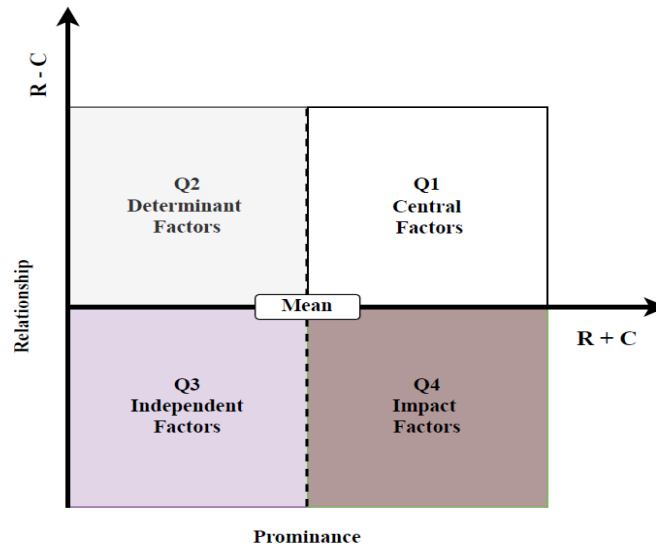


Figure 2: The causal graph

Step 5. Setting up the threshold value (α) and obtaining the causal-relation map.

To explain the structural relation among factors while keeping the complexity of the whole causal-relation map at a manageable level, it is necessary to set a threshold value (α) to filter out negligible effects in matrix T. The threshold value (α) was determined using the mean and standard deviation of the total relation matrix ($\alpha = \text{mean} + \text{SD}$). This approach is widely adopted in DEMATEL applications to filter insignificant relationships while preserving meaningful interactions among factors. For example, recent studies have explicitly applied the mean plus standard deviation method to identify significant causal links (Li & Tzeng, 2009). Moreover, the selection of threshold values in DEMATEL is generally data-driven and influenced by the distribution of influence values rather than being arbitrarily defined, ensuring that only the most relevant relationships are retained in the causal diagram (Hsieh et al., 2016). In this study, the threshold value was determined by adding the mean (2.41) and the SD (0.22) of the elements in total matrix T, $\alpha = 2.63$.

4. Result and Discussion

This study employed the DEMATEL approach to examine the causal relationships among critical success factors influencing the implementation and effectiveness of E-learning systems in higher education institutions. By analyzing the interactions among five key dimensions—students (F1), instructors (F2), design and contents (F3), system and technological infrastructure (F4), and institutional management (F5)—the findings reveal that E-learning success is governed by a structured network of interdependencies rather than isolated factors.

Table 5: Averaged cause-effect matrix

Averaged Cause-effect matrix	F1	F2	F3	F4	F5
F1	0.00	2.17	1.90	2.12	1.51
F2	2.59	0.00	2.44	2.22	2.10
F3	2.49	2.51	0.00	2.51	2.22
F4	2.51	2.51	2.32	0.00	2.20
F5	2.20	2.24	2.15	2.32	0.00

Table 6: Normalized cause-effect matrix

Normalized Cause-effect matrix	F1	F2	F3	F4	F5
F1	0.00	0.22	0.19	0.22	0.15
F2	0.26	0.00	0.25	0.23	0.21
F3	0.25	0.26	0.00	0.26	0.23
F4	0.26	0.26	0.24	0.00	0.22
F5	0.22	0.23	0.22	0.24	0.00

Table 7: Total cause-effect matrix

Total Cause-effect matrix	F1	F2	F3	F4	F5
F1	2.12	2.24	2.11	2.18	1.93
F2	2.68	2.40	2.46	2.52	2.27
F3	2.76	2.69	2.35	2.63	2.35
F4	2.72	2.64	2.50	2.38	2.31
F5	2.57	2.50	2.36	2.45	2.02

Table 8: The resulted relations between factors.

Factors	R	C	R+C	R-C	Group
F1	10.57	12.86	23.43	-2.29	Effect
F2	12.34	12.46	24.80	-0.12	Effect
F3	12.78	11.78	24.56	1.00	Cause
F4	12.56	12.16	24.72	0.40	Cause
F5	11.89	10.88	22.77	1.01	Cause

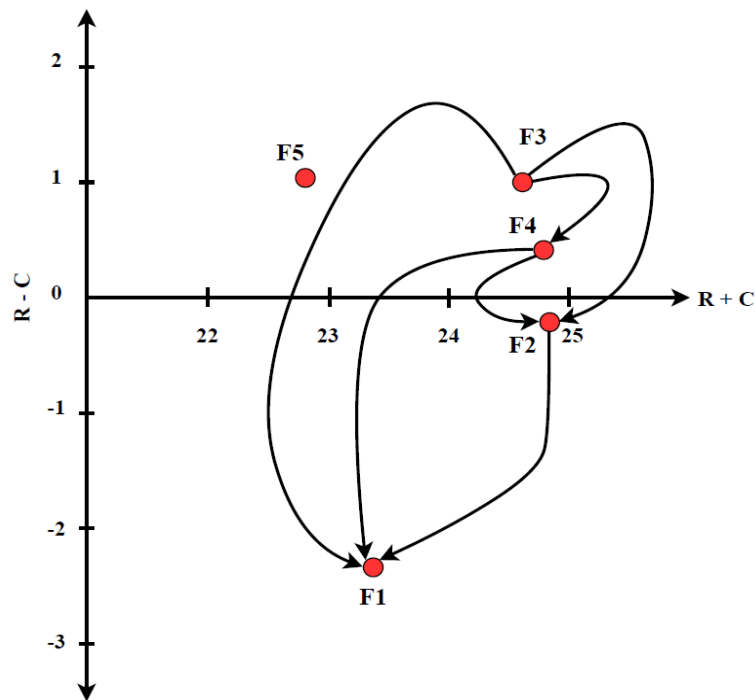


Figure 3: The DEMATEL map.

The results, reflected in the prominence ($R+C$) and relation ($R-C$) values, indicate a clear distinction between driving (cause) factors and dependent (effect) factors. Specifically, design and contents (F3), system and technological infrastructure (F4), and institutional management (F5) form the core causal group, while students (F1) and instructors (F2) are positioned within the effect group, suggesting that their performance is largely shaped by the surrounding system conditions. This causal structure provides a deeper interpretation compared to prior studies that primarily identify and rank critical success factors. For instance, findings related to the importance of system quality and content design are consistent with the work of Mohammad Al-Fraihat et al. (2020), who highlighted system quality, content quality, and institutional support as key determinants of E-learning success. Similarly, Pei-Chen Sun et al. (2008) emphasized the role of course design and technological factors in influencing learner satisfaction. However, unlike these studies, the present research extends the literature by identifying the directional influence among factors, demonstrating that improvements in design and content can trigger cascading effects across the entire E-learning system.

Among the driving factors, design and contents (F3) emerges as one of the most influential elements, confirming its central role in shaping E-learning effectiveness. This finding aligns with previous research suggesting that high-quality instructional design enhances learner engagement and satisfaction [39–41]. However, the present study goes further by demonstrating that instructional design is not merely important in isolation but acts as a primary causal driver that influences both technological usage and user engagement. This highlights its strategic importance in resource-constrained environments such as Libyan universities, where optimizing content quality can compensate for certain infrastructural limitations. The system and technological infrastructure (F4) also plays a critical causal role,

consistent with prior studies that emphasize system quality and technological readiness as key determinants of E-learning adoption [42,43]. However, the DEMATEL results provide additional insight by positioning technology as an enabling factor that supports and amplifies other dimensions, rather than functioning as an independent determinant. This suggests that technological investments alone may not guarantee success unless they are aligned with effective instructional design and institutional strategies. Institutional management (F5) is identified as another significant driver, supporting previous findings that highlight the importance of organizational support and governance in E-learning implementation [44,45]. The results indicate that institutional factors act as a coordinating mechanism, aligning pedagogical and technological components to ensure system effectiveness. This is particularly relevant in the Libyan context, where institutional readiness and strategic planning remain critical challenges affecting the adoption and sustainability of E-learning systems.

In contrast, students (F1) and instructors (F2) are categorized within the effect group. Although the instructors' dimension (F2) exhibits a slightly negative ($R - C$) value, placing it within the effect group, the magnitude of this value is minimal (-0.12), indicating a near-neutral role with weak dependence compared to more strongly affected factors such as students (F1), indicating that their performance is influenced by the quality of the supporting environment. This finding is consistent with studies showing that learner satisfaction and instructor effectiveness depend on system usability, course design, and institutional support [45–47]. However, the present study provides a more nuanced interpretation by demonstrating that these human factors are outcomes of system-level interactions, rather than primary drivers of success.

Overall, the findings highlight that E-learning success should be understood as a systemic and dynamic phenomenon, emerging from the interaction between pedagogical design, technological infrastructure, and institutional governance. This perspective extends prior research by moving beyond factor identification toward a causal and structural understanding, offering more actionable insights for improving E-learning effectiveness, particularly in developing-country contexts such as Libya. It is important to note that the causal relationships identified in this study are derived from aggregated expert judgments and should therefore be interpreted as perceptual rather than strictly deterministic. Given the subjective nature of the DEMATEL approach, variations in expert opinions or sample composition may lead to different structural outcomes. Accordingly, the results should be understood as indicative of the perceived interdependencies among factors rather than definitive causal relationships.

5. Implications

This study provides important theoretical and practical implications by revealing the causal structure of E-learning success factors using the DEMATEL approach within Libyan universities. From a theoretical perspective, the findings demonstrate that critical success factors operate as an interconnected causal system rather than independent elements. The identification of cause-and-effect groups highlights that design and content, system and technology, and institutional management act as key driving forces. This reinforces a systems-oriented understanding of E-learning and extends existing research by providing evidence from a developing-country context, where structural and technological constraints significantly influence system effectiveness. From a practical perspective, the results offer

actionable guidance for university decision-makers in Libya. Given the challenges related to limited ICT infrastructure, inconsistent internet connectivity, and varying levels of digital readiness, prioritizing high-quality design and content, strengthening technological infrastructure, and enhancing institutional support becomes essential for improving E-learning effectiveness. The findings also emphasize that interventions should be implemented holistically, as improvements in key driving factors can generate cascading effects across other dimensions of the system. At the policy level, this study highlights the need for targeted investment in digital education within Libya. Policymakers can utilize these insights to prioritize resource allocation, enhance institutional preparedness, and support capacity-building initiatives, thereby fostering the sustainable development of E-learning systems in resource-constrained environments.

6. Limitations and Future Work

This study has several limitations that should be considered. First, the sample size was relatively small and based on convenience sampling from selected Libyan universities, which may limit the generalizability of the findings. Although the participants had practical experience with E-learning systems, the selection criteria were not strictly controlled, which may introduce potential bias. In addition, the DEMATEL analysis relied on subjective participant evaluations, which introduces uncertainty, as the resulting causal structure may vary depending on the composition and perspectives of the respondents. Furthermore, the identified causal relationships were not validated against objective E-learning outcome measures, such as learner performance, satisfaction, or system usage data, which limits the empirical verification of the proposed influence structure. Future research may address these limitations by employing larger and more diverse samples, adopting more rigorous participant selection criteria, conducting sensitivity analysis to assess the robustness of the findings, and integrating DEMATEL with complementary methods such as Analytic Hierarchy Process (AHP), Analytic Network Process (ANP), fuzzy DEMATEL, or Structural Equation Modeling (SEM) to improve the validity, robustness, and empirical validation of the results across different contexts.

Conclusion

This study investigated the causal relationships among critical success factors influencing the effectiveness of E-learning systems in higher education institutions using the DEMATEL method. Five key dimensions were analyzed: students, instructors, design and contents, system and technological infrastructure, and institutional management. The results indicate that design and contents, system and technological infrastructure, and institutional management were perceived as the primary driving factors within the E-learning ecosystem. These factors were perceived to exert stronger influence on the performance of the remaining dimensions and therefore play a central role in determining the success of digital learning environments. In contrast, students and instructors were identified as dependent factors whose engagement and performance are largely influenced by the surrounding technological and organizational framework. These findings emphasize that the effectiveness of E-learning systems depends on the integration of pedagogical quality, technological readiness, and institutional support. Universities aiming to enhance digital learning outcomes should adopt a

comprehensive approach that simultaneously addresses these three critical dimensions. Despite its contributions, this study has certain limitations. The analysis relied on subjective participant evaluations and focused on a limited set of E-learning dimensions; therefore, the identified causal relationships should be interpreted as perception-based structural insights rather than objectively verified causal mechanisms. Future research could extend the model by incorporating additional variables such as learner satisfaction, digital literacy, system usability, and collaborative learning features. Moreover, empirical validation using large-scale datasets from students and instructors could provide deeper insights into the complex dynamics of E-learning adoption and performance. As the study was conducted within selected Libyan universities, the findings may be context-specific and should be generalized with caution to other educational environments.

In conclusion, this research contributes to the growing body of knowledge on digital education by providing a systematic evaluation of E-learning critical success factors through the DEMATEL framework. The findings offer valuable insights for policymakers, university administrators, and educational technology developers seeking to design more effective, resilient, and sustainable E-learning strategies in higher education institutions.

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