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# Evaluating and Prioritizing Barriers for Sustainable E-Learning Using Analytic Hierarchy Process-Group Decision Making

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**Abstract:** E-Learning is a popular computer-based teaching–learning system that has been rapidly gaining global attention during and post COVID-19. The leaping changes in digital technology have enabled E-Learning to become more effective in recent years. It offers freedom from restrictions caused by geographical boundaries and provides time flexibility in the teaching–learning process. Apart from its numerous advantages, the success of E-Learning depends upon many critical success factors (CSFs) and barriers. If the barriers that lie in the way of successful E-Learning implementation are not addressed diligently, it will limit E-Learning success. It has been revealed through past research that these barriers are serious threats that need immediate attention in their redressal. This paper attempts to reveal sixteen barriers under four different dimensions by going through a comprehensive review of the literature and engaging decision makers. Furthermore, it uses the Analytic Hierarchy Process-Group Decision Making (AHP-GDM) methodology to evaluate and prioritize them. The results obtained show that barriers related to the Institutional Management Dimension (BIMD), Infrastructure and Technological Dimension (BITD), Student Dimension (BSD), and Instructor Dimension (BID) pose the greatest challenges in the successful implementation of E-Learning. The AHP-GDM methodologies reveal the comparative relationship among these barriers as BIMD > BITD > BSD > BID and further quantify their negative effects as 46.35%, 29.88%, 12.30%, and 11.4%, respectively, on successful E-Learning systems (> indicates comparative challenges).

**Keywords:** analytic hierarchy process (AHP); barriers of e-learning; emergency remote education (ERE); group decision making (GDM); sustainable e-learning



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## 1. Introduction

The world has changed since COVID-19, the impact of the pandemic is expediting several trends in global education, business, and other domains. To deal with this situation, the United Nations Educational Scientific and Cultural Organization (UNESCO) recommended the use of distance/digital learning, which is more commonly referred to as E-Learning. E-Learning provides teaching–learning by using electronic media through the Internet as online learning. Online learning may be regarded as a kind of distance learning. Mobile learning provides a fun mode for teaching–learning through a smartphone. Digital learning provides teaching–learning through the use of information and communication technology (ICT), such as computers, smartphones, and the internet. All the modes enhance knowledge, performance, and ease of life when used efficiently. However, there is prevailing need for an E-Learning system for the sustainability of education [1].

E-Learning normally helps in providing education remotely without any physical contact between the teacher and the student [2]. E-Learning systems use the software in the teaching–learning process. The educational content is accessed remotely through an online platform, for example the Internet, satellite TV, etc., which requires consideration of interactive learning systems, such as virtual classrooms and proper infrastructure for digital communication.

E-Learning transforms the scope of international education and learning systems in higher education institutes [3]. It plays a vital role in enhancing the quality of teaching and learning in the university educational system [4,5]. During the pandemic, physical distancing and lockdown measures came into force. Accordingly, E-Learning has also been adopted by almost all universities in the Kingdom of Saudi Arabia (KSA), just like many other universities around the world.

Students at large benefit from the websites of an E-Learning system that provides education materials through the web-based system as compared with regular classroom teaching. The E-Learning system offers various communication tools such as discussion boards, a system to share text files, and e-mail [6]. Globally, many universities have been implementing E-Learning as a teaching–learning model [4]. Advancements in digital technology have improved the teaching–learning environment for different stakeholders such as instructors, students, and university administrators. Although an E-Learning system cannot entirely substitute the traditional teaching–learning methods, it can support the necessary learning to keep the academic sessions on track, as experienced in many countries such as China, India, and South Africa [7,8]. E-learning-based systems have many advantages. Resources such as time, money, and traveling to the educational institution can be optimized as well as provide freedom from fixed classroom teaching. E-Learning systems support and motivate students and teachers by making teaching–learning easy through multimedia and large databases [9]. Alam and Asimiran [10] carried out a study on graduates to compare the academic performance of online studies before and during COVID-19. The study confirmed that there is an increase in academic performance in comparison to job readiness. As per the study of Alam (2021) [1], there was much more dependency on online/digital technology to deliver courses and program outcomes. He further concluded that the situation gives rise to a ‘diploma crises’ crisis, which will create unimaginably significant long-term problems. Alavudeen (2021) [11] conducted an empirical study and found that medical students find difficulty in accepting E-learning due to psychological, social, and demographic situations. Kaymak and Horzum (2022) [12] considered student barriers to predict perceived learning and academic achievement.

Despite the profound merits of E-Learning in modern universities, there are some barriers to its successful implementation. E-Learning systems have been developed after substantially huge investments, though many researchers feel its use is still limited and incomplete [4,13–15]. Evidence also shows that in many universities E-Learning success is not directly proportional to the huge investment made for its effective implementation [16]. The long-term implementation, propagation, and use of E-Learning have not been as effective as initially expected. The contradiction between the growing public desire for it and their refusal to implement it has led researchers and practitioners to focus on the barriers to the implementation of E-Learning. Although considerable work has been conducted to identify the barriers to the adoption of E-Learning, there has been little work to incorporate this awareness into the system. Thus, to bridge the existing gap in the literature, the following research questions were formulated.

RQ1: What are the potential barriers that play a negative role in the E-Learning system? How can they be identified by reviewing the literature?

RQ2: How can these identified barriers to E-Learning adoption be evaluated and prioritised using an AHP-GDM-based methodology?

Based on the research questions, the current research focused on the following objectives:

1. To provide a comprehensive review of the literature to identify barriers to successful E-Learning.

2. To evaluate, prioritize, and rank the E-Learning barriers with the help of Analytic Hierarchy Process-Group Decision Making (AHP-GDM).

The main contribution of the present research is to provide a comprehensive review of the literature on barriers that hinder successful E-Learning implementation. The identified potential barriers to E-Learning are evaluated using MCDM-based research methodology. The present research provides an evaluation of identified barriers and their influence on the successful E-Learning system. The present research will help the university management, instructors, students, and other related stakeholders.

Various sections on the state-of-the-art literature review associated with Multiple Criteria Decision Making (MCDM) research methodologies, a framework for barriers related to E-Learning, the AHP methodology, the use of AHP-GDM in the present research, and resulting conclusions were documented. Section 2 shows the present study framework for prioritizing E-Learning barriers. It also documents the state-of-art literature review associated with MCDM-based research methodologies and barriers related to E-Learning. Section 3 illustrates the AHP-GDM methodology. Section 4 illustrates the case for using AHP-GDM methodology for ranking E-Learning barrier factors. Section 5 documents the discussions on the result of the ranking of barriers to E-Learning. Finally, this research study ends with the conclusions and future work in Section 6.

## 2. Framework for E-Learning Barriers

Numerous research studies have provided important insight into E-Learning through the study of critical success factors (CSFs) or enablers and barriers. In their attempt to study barriers and their adverse effect on E-Learning implementations, various researchers have categorized the barriers of E-Learning into several dimensions. Several frameworks proposed by researchers for E-Learning are found in the literature. The E-Learning barriers framework for their selection and subsequent prioritization using AHP-GDM methodology is depicted in Figure 1. The framework begins with the review of the literature. The E-Learning literature for barrier identification and AHP-GDM-methodology-related literature were studied. This is further divided into two subsections, namely MCDM-based research methodologies-related work and identification of E-Learning barriers along with E-Learning dimensions. A detailed literature review of selected dimensions and barriers is tabulated in Table 1.

**Table 1.** Barriers Factors.

Dimensions	Barrier Factors	Resources/References
Barriers related to Students' Dimension (BSD)	Lack of ICT Skills (SLIS)	[17–29]
	Lack of E-Learning Knowledge (SLEK)	[3,20,21,30,31]
	Lack of English Language Proficiency (SLELP)	[3,16,21,32,33]
	Lack of Motivation (SLM)	[3,21,30,33–37]
Barriers related to Instructors' Dimension (BID)	Lack of ICT Skills (ILIS)	[3,17,21–25,27–32,35,38,39]
	Lack of E-Learning Knowledge (ILEK)	[21,23,30,34,40]
	Instructors Resistance to Change (IRC)	[3,17,22,23,31,41,42]
	Lack of Time to Develop E-Courses (ITDE)	[3,16,19,22,24,27–30,36,37,41,43,44]
Barriers related to Infrastructure and Technology Dimension (BITD)	Lack of Motivation (ILM)	[21,23,28,29,38,44]
	Inappropriate Infrastructure (ITII)	[3,17–21,23–25,27–32,37,39,40,44–48]
	Low Internet Bandwidth (ITIB)	[21,23,25–27,29,33,37,39,44,47,49]
	Lack of Technical Support (ITTS)	[16,21,26,28,31,40,41,43,44,47,50,51]

Table 1. Cont.

Dimensions	Barrier Factors	Resources/References
Barriers related to Institutional Management Dimension (BIMD)	Lack of Financial Support (IMFS)	[3,20,21,24,25,28,31,33,35,38,39,42,52,53]
	Lack of Inadequate Policies (IMIP)	[16,20,21,23,24,31,38,39,46,52]
	Lack of Training on E-Learning (IMTE)	[3,16,17,20,21,31,37,38,41,47]
	Lack of Instructional Design (IMID)	[16,38,44,46]

Key: Lack of ICT Skills (ILIS), Lack of E-Learning Knowledge (ILEK), Instructors Resistance to Change (IRC), Lack of Time to Develop E-Courses (ITDE), Lack of Motivation (ILM), Inappropriate Infrastructure (ITII), Low Internet Bandwidth (ITIB), Lack of Technical Support (ITTS), Lack of Financial Support (IMFS), Lack of Inadequate Policies (IMIP), Lack of Training on E-Learning (IMTE), and Lack of Instructional Design (IMID).

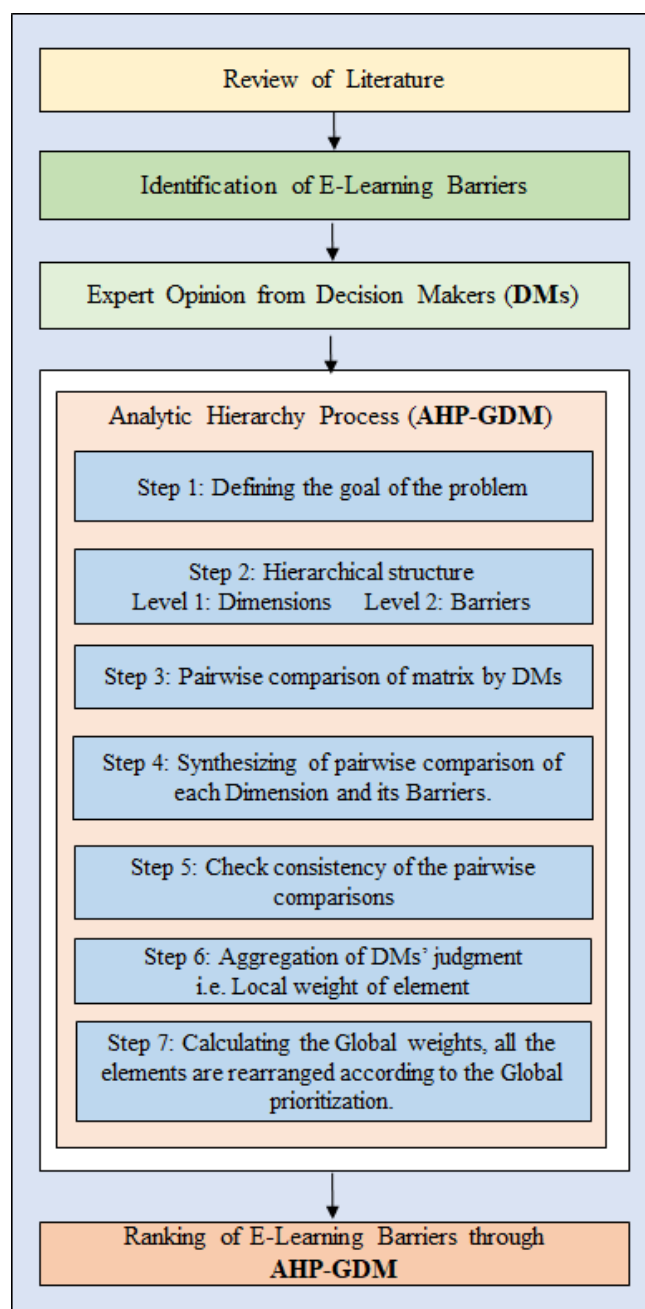


Figure 1. E-Learning barriers' framework for selection and prioritization through AHP-GDM.

Several research studies have focused on barrier factors related to E-Learning. This section is divided into two subsections, namely MCDM-based research-methodologies-related work and identification of barriers related to different E-Learning dimensions.

### 2.1. MCDM-Based Research-Methodologies-Related Work

In addition to exploring the barriers to E-Learning, a literature review on multiple models is performed and reported in this section. Several researchers have implemented a methodology that focused on MCDM. Gupta et al. [54] implemented the AHP model to define and check the quality of the E-Learning system. They deployed the weight and rank E-learning quality requirements that are vital for stakeholders to observe, such as educators, accreditation bodies, and institutional management. They found that the E-Learning system is successful irrespective of the type of educational system i.e., part-time, full-time, and distance education program.

Jeong and Yeo [55] used AHP's comparison function to identify and evaluate the use of multimedia-based E-Learning content and created a model using multimedia factors. This work extracted nine different criteria for the model presentation from previous research studies. Yigit, Isik, and Ince [56] applied AHP to their study. The web-based software SDUNESA uses AHP's parameters for the selection of learning objectives. They are defined and explained under computer education priorities. The AHP's parameters save time in searching for a large database for learning objectives. The AHP-based research methodology has been frequently used in the analysis of various aspects of E-Learning.

The strategic development of E-Learning systems is used with decision making on the most appropriate types of E-Learning systems at various levels. Mohammed, Kasim, and Shaharane [57] surveyed a panel of 95 respondents consisting of administrative and academic personnel and graduates in Malaysia. They were asked to assess and rate the performance of five identified E-Learning systems. They concluded that strategic readiness for E-Learning implementation was the most important criterion among the human resources, specific information, and Communications Technology (ICT) infrastructure, basic ICT infrastructure, and legal and formal readiness for E-Learning implementation. They also found that a flipped classroom is the most suitable E-Learning approach. Their study helps the school administration to meet its requirement of establishing a new approach to select suitable alternatives of teaching–learning.

Based on the literature review, AHP-GDM research methodologies have been applied in analyses when different factors and aspects are available in decision making. Nevertheless, incorporating technological innovation into education is not without obstacles. Even in developed countries and cities, in day-to-day teaching and learning, there are obstacles when using technology [40]. Consolidating E-Learning into conventional education is a reasonably troublesome task that may run into various sorts of confusion and troubles. These issues are considered as obstacles or barriers to coordinating E-Learning with traditional educational fields, making it difficult for E-Learning to succeed [16]. If one recognizes these barriers and hindrances, one can pay particular attention to them when using the E-Learning system and make the E-Learning application robust, foolproof, and successful [9,51].

Al-Azawei, Parslow, and Lundqvist [21] and Bringula et al. [58] identified various student dimensions, and Gcora and Cilliers [52], Smy, Cahillane, and MacLean [22] and Tarus, Gichoya, and Muumbo [39] discovered various barriers in instructor dimensions.

Al-Azawei et al. [21], Al Gamdi and Samarji [16], and Stoffregen et al. [20] found different barriers related to the infrastructure and technological dimensions. Many researchers also discovered that different barriers related to the institutional management dimension are also significant for successful E-Learning [47,52]. To identify the barriers to successful E-Learning, a systematic review of the literature was carried out. The various barriers are identified and grouped into four dimensions, namely student, instructor, infrastructure and technology, and institutional management. These barriers are further subcategorized into 16 factors.



## 2.2. The Identification of Barriers Related to Different E-Learning Dimensions

Based on the literature review and successive framework, the following four different barrier dimensions are identified.

### 2.2.1. Student Barriers

The critical move from traditional teaching and learning to E-Learning has immensely increased because of its various advantages. It has become crucial as students are limited to their homes and do not have access to university classrooms, laboratories, and libraries. Even though E-Learning has received much acclaim, a human instructor can never be replaced by a computer system. Students play a significant role in the E-Learning system. In E-Learning, instructors and students are at a distance from each other, so various challenges reduce their eagerness to use the E-Learning system [34]. Different barrier factors are found in the literature for student dimensions, such as lack of information and communication technology, lack of ICT skills [17,18,22,30], lack of E-Learning knowledge [31], lack of English language proficiency [16], and lack of motivation [30]. Assareh and Bidokht [34] carried out a study at Jerash University on 230 male and 170 female students. They discussed the effectiveness of online learning and whether enjoyment from online learning was a major barrier from a student's perspective. Based on the series of semistructured interviews with E-Learning experts from Tanzanian Higher Learning Institutions (HLIs), it was found that the major five barriers are poor infrastructure; financial constraints; inadequate support; lack of E-Learning knowledge; and teachers resistance to change [31]. A 214-question questionnaire-based study revealed that the lack of adequate English language proficiency was a barrier from a student's perspective [16].

### 2.2.2. Instructor Barriers

The instructor is considered a significant dimension of E-Learning. Some instructors are less familiar with E-Learning. They require proper training in utilizing technology for web-based online courses. Some even have less confidence in utilizing ICT technologies in education [30,40]. In this unusual situation of COVID-19, instructors must be given the necessary training and should possess skills for using E-Learning tools. This training is being given to instructors through E-Learning now. When they gain proper knowledge, their level of confidence may increase to use the new electronic devices and deliver education with the help of web-based technology. Some studies have also found that instructors' attitude changes positively after receiving the required training in hardware, software, and organization of delivering the material in the E-Learning system [47].

Different research studies found various E-Learning barriers related to the instructor dimension, for example, lack of ICT skills [17,38]. Many instructors are at the early stage of their career and do not possess enough ICT skills, making them handicapped in using the E-Learning system. It is important to note that training should be provided to instructors as well as to students to make them ICT proficient so that they can derive maximum benefits from the E-Learning system [59].

Lack of E-Learning knowledge translates into insufficient experience in operating the E-Learning system. Al-Azawei et al. [21], in their study, identified barriers such as inadequate training programs, lack of technical support, ICTs, and E-Learning illiteracy and lack of awareness, interest, and motivation toward E-Learning technology. In their findings, they concluded many instructors lack skill and experience in using the Learning Management System (LMS). Because of this deficiency, it becomes difficult for them to engage in class using the LMS system. Some instructors find it difficult to share teaching materials and manage other teaching–learning activities such as taking attendance, online exams, grading tests and assignments, and monitoring students. Based on the quantitative and qualitative research methodology, it appears that many senior faculties find it difficult to use the LMS system [59]. Hence, they prefer not to change their teaching methods from traditional classroom teaching to E-Learning systems. In E-Learning, the human dimension plays a significant role and influences its outcome. Therefore, universities must

strive to take the human dimension into consideration while removing the barriers to the E-Learning system. Based on the Nigerian Higher Education Institutes (HEIS) case studies [42] and a study based on a series of semistructured interviews with Tanzanian HLLs [31], resistance to change is one of the barriers present in the senior faculties, who prefer traditional classroom teaching to E-Learning. It is difficult for them to adopt a new system. Since they are well-conversant with traditional teaching–learning methods, they do not see the need or the urgency of using E-Learning. Thus, they are reluctant to change to a new E-learning system. Lack of time to develop E-courses was revealed during a 214-question questionnaire-based study [16], where an integrative review was conducted over three months by an interinstitutional research team [19]. It is a common barrier and faced by both young and senior instructors. Course materials must be developed systematically to suit the LMS system requirement so that students can easily download, study, and understand them. Most instructors do not have time to develop E-courses due to their additional teaching hours, extracurricular, and administrative activities.

Many instructors are not motivated to take more initiatives to adopt the E-learning system because of insufficient skill, time, salary structure, lack of promotions, experience, and training [21].

### 2.2.3. Infrastructure and Technological Barriers

Lack of a robust and proper infrastructure and updated technology is considered as the most challenging barrier dimension for successful E-Learning implementation [38,40]. This includes having the latest hardware and software programs [30], a high-speed connection to the Internet, an uninterrupted power supply, a regular and capable maintenance system, and general support from the administration of the Internet provider organization [60]. The shortage of these components may generally cause a big disappointment in the E-Learning system [47,60]. Other studies reported that hardware equipment, the capacity of data transfer of the E-Learning system, and proper software for the system vastly influence the success of E-Learning implementation [19].

### 2.2.4. Institutional Management Barriers

Lack of institutional management care and commitment is an important barrier [38]. The management of an institution may differ in its strategic decision making to implement an E-learning system because of a lack of technical knowledge and trust in E-Learning. The investment priority may shift or differ [60]. Other studies have also identified different barriers of institutional and management support dimensions, such as lack of proper policies and support, lack of financial support, and lack of proper training for all users [17].

## 3. Overview of AHP-GDM Research Methodology

The present research study uses the AHP-GDM methodology in evaluating and prioritizing the E-Learning barriers by considering the case study which is illustrated in the following section. The AHP-GDM provides the pairwise comparison judgment of Decision Makers (DMs) in crisp form and eases comparison and fine-tuning of the results. The detailed steps are further described as follows.

### 3.1. AHP-GDM Methodology

AHP-GDM was developed by Saaty [61] for the systematic decision support technique. The AHP helps in dealing with composite, unstructured, and multiple criteria-based problems for decision making. Many research studies have applied the AHP in a wide variety of decision areas [62–64].

In AHP, expertise and understanding are used to formulate the final opinion. For the pairwise comparison, the opinion of the expert is considered. If a single DM provides an opinion in the AHP, it can be biased and lead to misleading judgment. GDM may be used to eliminate this bias. Several DMs may be utilized for pairwise comparison which cannot be biased. The Geometric Mean (GM) can be calculated by synthesizing the

decisions made by different DMs. The resulting final synthesized decision matrix is more reliable than the single DM. Table 2 depicts Saaty's scale, which is intended for the pairwise comparison matrix.

**Table 2.** Nine-point scale [61].

The Intensity Importance	Definition
1	Equally preferred
3	Moderately preferred
5	Essentially preferred
7	Very strongly preferred
9	Extremely preferred
2, 4, 6, 8	Intermediate importance between two adjacent judgments

### 3.1.1. Step 1

All barrier factors with their respective dimensions are grouped to form the decision comparison matrix 'D'. Every component of the matrix 'D' is linked to Saaty's scale. Each component of the matrix 'D',  $d_{pq}$ , compares the importance level of the  $p$ th technical requirement with that of the  $q$ th.

$$D = \begin{bmatrix} d_{11} & d_{12} & \dots & d_{1k} \\ d_{21} & d_{22} & \dots & d_{2k} \\ \vdots & \vdots & \ddots & \vdots \\ d_{k1} & d_{k2} & \dots & d_{kk} \end{bmatrix} \quad (1)$$

### 3.1.2. Step 2

The GM of each of the rows for both the decision matrix and pairwise comparison matrices are calculated. The priority vector (P.V.) values follow the normalization of each GM value.

### 3.1.3. Step 3

An overall summation of the product of the sum of each vector column for both the decision matrix and pairwise comparison matrices containing the P.V. values of each row is carried out to obtain the principal eigenvalue ( $\lambda_{max}$ ), i.e.,

$$\lambda_{max} = \sum_{i,j=1}^k C_j PV_i \quad (2)$$

where  $C_j$  is the sum of each column vector.

### 3.1.4. Step 4

The Inconsistency Index (I.I.) of each pairwise comparison matrix is checked using Equation (3):

$$I.I. = \frac{\lambda_{max} - n}{n - 1} \quad (3)$$

Here, the number of matrix elements is denoted by  $n$ .

### 3.1.5. Step 5

Random Index (R.I.) [61] is determined for each of the square matrices using Equation (4). R.I. calculated values are also available as a ready reckoner documented in Table 3.

$$R.I. = \frac{1.98(n - 2)}{n} \quad (4)$$



**Table 3.** Random Index (R.I.).

Matrix Size ( <i>n</i> )	1	2	3	4	5	6	7	8	9	10
R.I.	0	0	0.58	0.09	1.12	1.24	1.32	1.41	1.45	1.49

### 3.1.6. Step 6

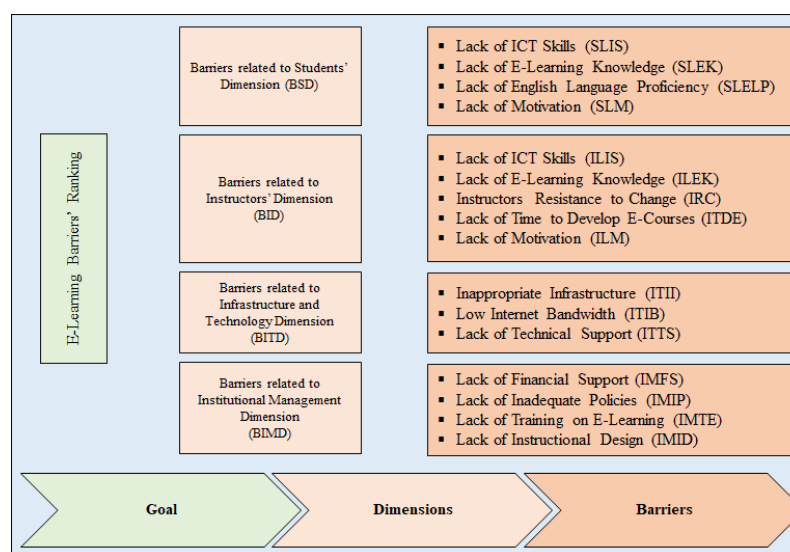
The Inconsistency Ratio (*I.R.*) for each of the square matrices is obtained by dividing *I.I.* value with *R.I.* values. A further revision of the matrix elements is needed if the inconsistency ratio is >10%.

### 3.1.7. Step 7

A pairwise comparison matrices ( $A_i, i = 1, 2, \dots, n$ ) Table 2 is used to assign a weight to these matrices. The P.V. values, principal eigenvalues, *I.I.*, and *I.R.* are calculated using the logic which is shown in steps 2–6.

## 4. Case Illustration Using AHP-GDM Methodology for Ranking E-Learning Barrier Factors

After constructing the structure depicted in Figure 2, the next step was to determine the relative contribution of each barrier factor with their respective dimensions. Three DMs were identified with more than six years of teaching experience in E-Learning. One DM had E-Learning experience of teaching engineering courses that involved theory and practice, whereas the other two DMs were from the computer science and science faculty. The DM carried out the pairwise comparison to ascertain the weight. There were three observers who played a significant role in the AHP-GDM methodology. The pairwise comparisons made by expert DMs were reviewed. The various AHP-GDM requirements, for instance, use of Saaty's scale and consistency in decision making, were ensured. Once the observers were satisfied, they okayed the pairwise table for further analysis. Under AHP, the expert's knowledge is used to formulate a final opinion. Before considering the final opinion, the pairwise judgment was critically observed by three observers for their final acceptance. The expert's judgment and observer's responsibility, as shown in Table 4, play a significant role in establishing final relationships among E-Learning barriers.

**Figure 2.** Hierarchical structure of E-Learning barrier factors.

**Table 4.** Profiles of Decision Makers and Observer.

Sr. No.	Participants' Role	Job Designation	Experience (Total/E-Learning)	Responsibility in the Present RESEARCH
1	DM 1	Professor	30/12	Establishing relationship among barriers of E-Learning.
2	DM 2	Associate Professor	13/8	Establishing relationship among barriers of E-Learning.
3	DM 3	Associate Professor	10/7	Establishing relationship among barriers of E-Learning.
4	Observer 1	Dean of E-Learning	12/8	Verifying relationship among barriers of E-Learning.
5	Observer 2	Vice Dean of E-Learning	10/7	Verifying relationship among barriers of E-Learning.
6	Observer 3	College Vice Dean	9/7	Verifying relationship among barriers of E-Learning.

In AHP, GDM may be used with different DMs for pairwise comparison. Saaty's scale, as shown in Table 2, is used for the pairwise comparison matrix. Consequently, various DMs pairwise decisions are synthesized using the GM method.

The decision matrix obtained after synthesizing provides more accuracy than that obtained by a single DM. Table 5 shows the pairwise comparison matrix of all the barrier dimensions provided by each expert DM.

**Table 5.** Barrier dimensions' pairwise comparison by each DM.

		BSD	BID	BITD	BIMD	Eigen Values
DM1	BSD	1	3	1/4	1/4	0.12543
	BID	1/3	1	1/5	1/5	0.064535
	BITD	4	5	1	1/2	0.336111
	BIMD	4	5	2	1	0.473924
$\lambda_{max} = 4.157912$ , CI = 0.789478, RI = 0.90, CR = 0.057879						
		BSD	BID	BITD	BIMD	Eigen value
DM2	BSD	1	1/2	1/4	1/5	0.080191
	BID	2	1	1/2	1/4	0.144324
	BITD	4	2	1	1	0.342174
	BIMD	5	4	1	1	0.433311
$\lambda_{max} = 4.047312$ , CI = 0.761828, RI = 0.90, CR = 0.017341						
		BSD	BID	BITD	BIMD	Eigen value
DM3	BSD	1	2	1	1/3	0.185082
	BID	1/2	1	1/4	1/3	0.097996
	BITD	1	4	1	1/3	0.231897
	BIMD	3	3	3	1	0.485025
$\lambda_{max} = 4.185418$ , CI = 0.7963545, RI = 0.90, CR = 0.067961						

Here,  $\lambda_{max}$  refers to the maximum eigenvalue. The CR is a consistency ratio and RI is a random index, whereas CI shows the consistency index.

After constructing the pairwise comparison tables, they were synthesized using geometric mean (GM). Table 6 shows the synthesized values of the pairwise comparison for the main barrier dimensions based on the judgment provided by DMs.

**Table 6.** Synthesizing of pairwise comparison of barrier dimensions.

Barriers Dimensions of E-Learning	BSD	BID	BITD	BIMD	Eigen Value
BSD	1	1 4/9	2/5	1/4	0.123017
BID	2/3	1	2/7	1/4	0.097002
BITD	5/2	3 3/7	1	5/9	0.298773
BMD	4	4	1 4/5	1	0.463544
$\lambda_{max} = 4.0259$ , CI = 0.0086, RI = 0.9000, CR = 0.0096					

In the next step, the consistency level of the pairwise comparisons was checked with the help of the CI and RI. Table 3 shows the RI values for different matrix sizes. The multiple values provided by different DMs may be aggregated in a single value in the relevant matrix. Thus, the weighted GM method was applied to aggregate the judgment of all three DMs. All three DMs are senior faculties with university teaching experience of more than ten years. In addition to this, DMs also possess an E-Learning teaching experience of more than five years. One of the DMs has E-Learning teaching experience in engineering courses, whereas the remaining two DMs have E-Learning teaching experience in computer science courses. Similarly, the aggregation process synthesized all the value of E-Learning dimensions and barriers. Table 7 shows the aggregated synthesized values of the dimensions.

In the final step, the barriers from all dimensions were ranked based on their global weights that were determined as a relative contribution. Finally, two different types, i.e., “local weights” and “global weights” were found. “Local weights” refer to the synthesizing value of the preceding hierarchical tier, while “global weights” are the synthesizing value of the top hierarchical level referred to as the goal.

To obtain the final ranking of the barriers, AHP associated the priority weights of the dimension with the comparison ratings for the factor to find the local and global ranking [65]. This is performed by the following equation:

Global weights =  $\sum$  (local weight for dimension  $i \times$  local weight for factor  $j$  with respect to dimension  $i$ )

**Table 7.** Synthesizing of barriers of dimensions after aggregation.

Dimensions of E-Learning	Eigenvalue
BSD	0.1230
BID	0.1147
BITD	0.2988
BIMD	0.4635
$\lambda_{max} = 4.0259$ , CI = 0.0086, RI = 0.90, CR = 0.0096	

Table 8 shows the aggregation of the barriers in all 4 dimensions, respectively, calculated the same way.

**Table 8.** Barriers after Aggregation under each Dimension.

Dimensions	Barriers	Local Weights	Consistency Check Values
Barriers of the Student Dimension (BSD)	SLIS	0.2175	$\lambda_{max} = 4.0553$ , CI = 0.0184, RI = 0.9000, CR = 0.0205
	SLEK	0.1084	
	SLELP	0.1131	
	SLM	0.5384	
Barriers of the Instructor Dimension (BID)	ILIS	0.2859	$\lambda_{max} = 5.3390$ , CI = 0.0847, RI = 1.12, CR = 0.0757
	ILEK	0.0362	
	IRC	0.1562	
	ITDE	0.1214	
	ILM	0.3889	
Barriers of the Infrastructure and Technological Dimension (BITD)	ITII	0.6696	$\lambda_{max} = 3.0200$ , CI = 0.0100, RI = 0.58, CR = 0.0173
	ITIB	0.2482	
	ITTS	0.0730	
Barriers of the Institutional Management Dimension (BIMD)	IMFS	0.6476	$\lambda_{max} = 4.1854$ , CI = 0.0618, RI = 0.90, CR = 0.0687
	IMIP	0.0776	
	IMTE	0.2176	
	IMID	0.0545	

Key: Lack of ICT Skills (SLIS), Lack of E-Learning Knowledge (SLEK), Lack of English Language Proficiency (SLELP), Lack of Motivation (SLM), Lack of ICT Skills (ILIS), Lack of E-Learning Knowledge (ILEK), Instructors Resistance to Change (IRC), Lack of Time to Develop E-Courses (ITDE), Lack of Motivation (ILM), Inappropriate Infrastructure (ITII), Low Internet Bandwidth (ITIB), Lack of Technical Support (ITTS), Lack of Financial Support (IMFS), Lack of Inadequate Policies (IMIP), Lack of Training on E-Learning (IMTE), Lack of Instructional Design (IMID).

The final calculated weights and rankings are presented in Table 9.

**Table 9.** Pairwise Comparison of E-Learning Barriers using AHP-GDM.

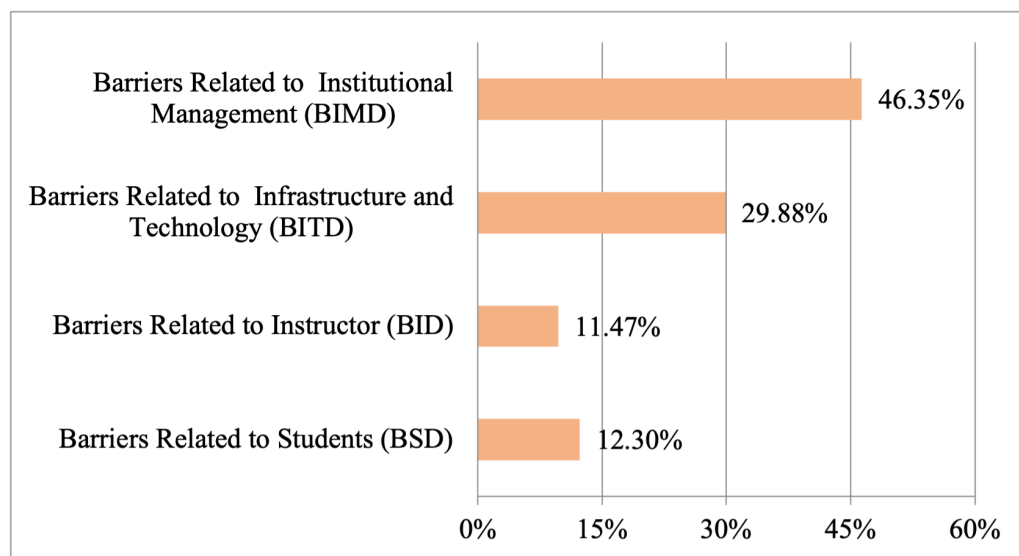
Dimensions	Dimension Weight	Barriers	Local Weights	Global Weights	Rank
Student Barriers (BSD)	0.1230	SLIS	0.2175	0.0268	9
		SLEK	0.1084	0.0133	14
		SLELP	0.1131	0.0139	13
		SLM	0.5384	0.0662	5
Instructor Barriers (BID)	0.1147	ILIS	0.2859	0.0277	8
		ILEK	0.0362	0.0035	16
		IRC	0.1562	0.0152	12
		ITDE	0.1214	0.0118	15
		ILM	0.3889	0.0377	6
Infrastructure and Technological Barriers (BITD)	0.2988	ITII	0.6696	0.2001	2
		ITIB	0.2482	0.0742	4
		ITTS	0.0730	0.0218	11
Institutional Management Barriers (BIMD)	0.4635	IMFS	0.6476	0.3002	1
		IMIP	0.0776	0.0360	7
		IMTE	0.2176	0.1009	3
		IMID	0.0545	0.0252	10

## 5. Results and Discussion

The main objectives of the present research were to identify and prioritize the barriers to successful implementation of an E-learning system based on the AHP-GDM methodology.

The various dimension weights are obtained and shown in Figure 3. Among the four dimensions, i.e., BIMD, BITD, BID, and BSD, the BIMD was found to be the most hindering

to the E-learning system. The other barriers found in decreasing order are BITD, BSD, and BID, in order of their hindrance to E-learning systems. The relationship ship  $BIMD > BITD > BSD > BID$  was obtained at the end of the results. The ‘>’ indicates more influence than the counter barriers. The relationship of  $BIMD > BITD > BSD > BID$  barriers was quantified in percentage weights as  $46.35 > 29.88 > 12.30 > 11.47$ .



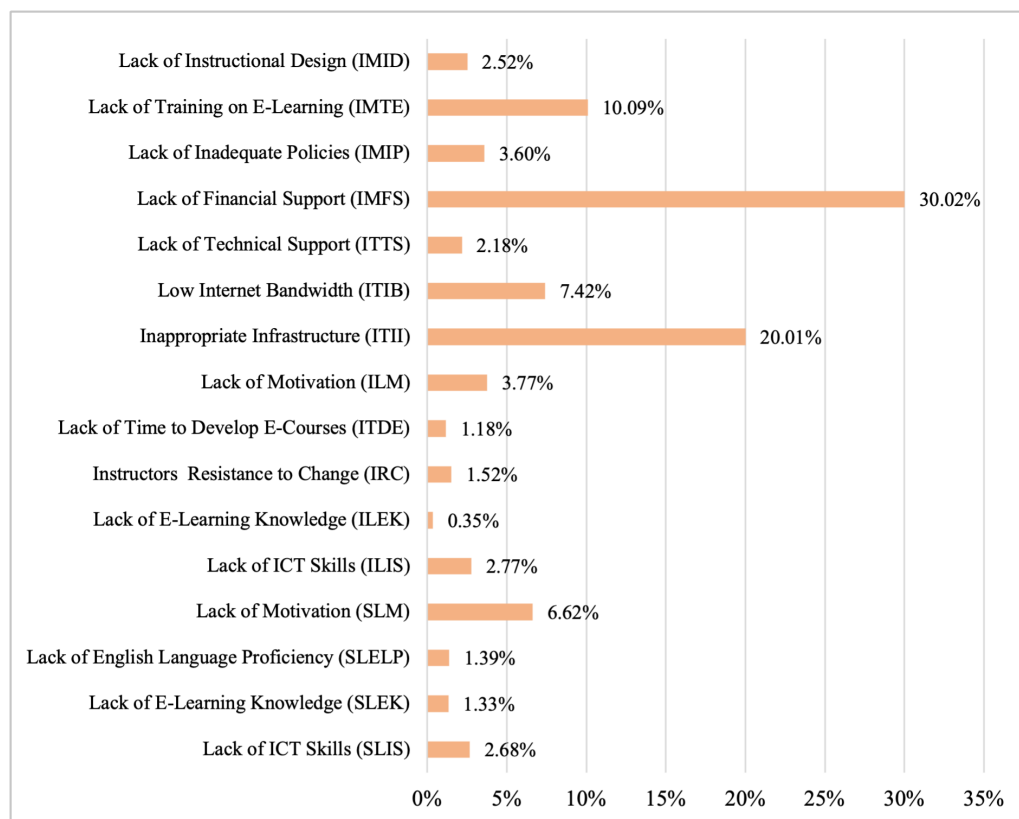
**Figure 3.** Barrier dimensions with their contribution.

The final weight of subfactors derived for 16 subfactors also influences the E-learning system. It is observed from Figure 4 that there are three major factors: IMFS, IIFS, and ITSS. These three constitute 60% of the total influence as compared with the remaining one.

The main stakeholders of an E-learning system to deliver teaching–learning in an effective way are institutional management, instructors, and students. The results obtained clearly indicate that the support of institutional management is crucial in supporting the E-Learning system. Failing to support the implementation of the E-learning strategy poses the biggest hurdle. The instructors are on the delivery end, whereas the students are on the receiving end, thus, they influence the E-learning system. The results show that the influence of the instructor and students is equally influential on the E-Learning system. Lack of experience in the E-Learning teaching–learning system influences the perceptions towards the adoption of E-Learning, hence instructors and students both provide threats to successful E-learning [11]. The necessary trained manpower may also influence the perception of students towards E-Learning as well. Training enhances the confidence level of instructors in conducting online classes in a comfortable mood. Based on the obtained results, it can be concluded that, in an E-Learning system, there are three stakeholders. BIMD, BID, and BSD constitute about 70% of the negative impact on the E-Learning system. If they are controlled, the 70% impact of such barriers that may be hindering the success of the E-Learning system may be removed.

The barrier of infrastructure and technology is the third worst barrier influencing the E-Learning system. It may be considered as the backbone of the E-learning system. In the absence of infrastructure, the necessary computer hardware and software support required to deliver the effective teaching–learning is hindered. The latest version of computer hardware along with up-to-date software helps in accomplishing teaching and learning in an effective manner. The time consumed in transferring the knowledge is largely reduced on an updated computer as compared with an older computer system. The latest software not only increases the software usage speed but also enhance the users’ experience. Thus, the students and instructors are motivated to engage themselves more in an effective manner. The Internet communication technology (ICT) has undergone a dynamic revolution and changed the computer world to take the giant steps towards

the digital age. Digital technology has helped to enhanced computing speed. Finally, our studies conclude that the more barriers there are, the more difficult it is to achieve E-learning objectives, which is in line with the results of Kaymak and Horzum (2022) [12]. The technological barriers significantly affect the learners' willingness to opt for online learning, which is also supported by past study [66].



**Figure 4.** Influence of E-Learning barriers.

#### Managerial implications and limitations:

The result of the present research identifies various barriers to the E-Learning system in KSA and are also similar to the findings in study [67]. The results of this study can assist policymakers for higher education studies, university authorities, and government ministries and related stakeholders. It can also help with designing and evolving new E-Learning courses so that they can be used successfully. Because of the prevailing COVID-19 pandemic, many universities in KSA still prefer the E-Learning system, hence the present study will help them to remove all the E-Learning barriers to make the system successful. The barriers of BIMD must be removed by the management to make a positive and encouraging environment in the universities. The Kingdom of Saudi Arabia (KSA) is attempting to enhance the infrastructure for E-learning. The management must devise sound systems to introduce E-Learning courses to gain the advantage of E-Learning. Instructors and supporting staff must undergo periodical training on a regular basis to gain the advantage of changing technology. The present study holds some limitations.

## 6. Conclusions and Future Work

The E-Learning system is subjected to various barriers and dimensions as they play an important role in a successful E-Learning system. It is important to analyze E-Learning barriers and their effect on teaching and learning outcomes. It is generally the management whose objectives, missions, and vision take a university to the lead role. Institutions also play a vital role in connecting teachers to their students through the E-Learning platform. The communication gap, due to institutional inefficiency, may widen further and make



it difficult for students to reach educators. The overloading of courses for instructors may create a hurdle in the interaction with students and peers. Institutions also need to adopt sound policies and practices to enhance student welfare schemes. Lacking strategic decision making and failing to provide state-of-the-art infrastructure slows down the use of the E-Learning system. E-Learning barriers may also change based on social, financial, and regional circumstances. Studying the barriers to E-Learning adoption is significant but challenging as well. The present research of evaluating the E-Learning barriers is based on the studies that have been carried out in KSA, and hence may be applicable to similar geographic conditions and cultures around the globe.

The present study is based on the judgmental decisions of DMs, so there may be a subjective bias. We adopted GDM to reduce the risk of subjective bias. The subjective bias can still be reduced by employing more DMs. Thus, an expert team with more DMs can be included in assessing and prioritizing E-Learning barriers through MCDM. Fuzzy-based MCMD can be used to reduce ambiguity and judgmental bias in decision making. Future research may also include more barriers based on empirical studies, as it will be helpful to reveal new significant barriers. In-depth analysis of such identified barriers can further be supported through structure equation modeling (SEM).

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