The Challenges of E-learning Implementation in Sudanese Universities from a Student's Perspective Using K-Means Algorithm

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Abstract:

E-learning provides educational services to individuals in rural or nomadic areas, as well as to traditional university and school students. Various communication technologies can be deployed to resolve spatial limitations; however, these same technologies introduce supplementary dilemmas, such as high costs and limited network coverage. Given these difficulties in delivering basic e-learning services, this paper provides an overview of research regarding factors affecting the successful implementation of e-learning in Sudanese universities, while classifying its core challenges. The analytical methodology utilizes the K-Means algorithm to prioritize the significance of these challenges. The results illustrate that technical issues are prioritized in the following order: internet services (cost and quality), data security, support for e-learning applications, and training.

Keywords: Education, Internet, E-Learning, E-Learning Challenges, K-Means, Weka.

1. Introduction:

With the massive evolution of various technologies, learning is no longer restricted to traditional classrooms where lecture delivery is the sole method of conveying knowledge. E-learning has recently emerged as a vital service to facilitate the education process, making learning accessible anywhere via communication networks and reducing educational losses—especially for students who are otherwise unable to continue their university education. It also promotes transparency as a modern educational requirement. Consequently, governments worldwide have worked diligently to harvest these benefits by creating frameworks that encompass people, strategies, processes, and technology, alongside robust action plans to ensure successful implementation (Chen et al., 2006).

In Sudan, e-learning was not widely adopted initially; however, political events, the COVID-19 pandemic, and subsequent conflicts acted as primary catalysts prompting Sudanese universities to transition toward e-learning. Like other technologies, e-learning suffers from several hurdles, most notably application functionality, system security, and overall service reliability. E-learning functions as an integrated system, and the seamless integration of its components is critical to its success (Mangaroska et al., 2021).

2. Literature review:

E-learning has become increasingly prevalent due to its ability to streamline educational processes and provide accessible learning experiences. By leveraging modern technologies, e-learning introduces innovative educational methods; however, it also presents distinct challenges.

Research indicates that key drivers of e-learning success include its capacity to encourage student learning and foster higher levels of engagement (Wang & Wang, 2009; Hardaker & Singh, 2011; Macharia & Pelser, 2012). When properly designed, e-learning can surpass traditional face-to-face methods by offering superior interaction quality, timely feedback, and the elimination of geographical barriers (Chen et al., 2006). Since then, extensive research and case studies have focused primarily on student needs, generating recommendations and solutions to enhance learning outcomes. For instance, Macharia and Pelser (2012) examined computing technology in Kenyan higher education, providing valuable insights into the factors influencing student acceptance of e-learning. They concluded that technology availability, access, and the character of institutional leadership are essential for successful e-learning diffusion (Eynon, 2005; Olaniran, 2006).

Despite this, limited research addresses the perspective of academic staff compared to students, particularly regarding the pressures placed on instructors by administrators to incorporate technology into active learning—especially within the UK context. Other studies emphasize the critical role of instructors, alongside infrastructure challenges such as equipment availability and internet connectivity (Basar et al., 2021; Miyazoe, 2022). Furthermore, numerous scholars have highlighted platform limitations, application development, and the transition from web-based frameworks toward mobile integration (Mangaroska et al., 2021; Azeta et al., 2008; Islam et al., 2015; Villegas et al., 2020).

Recent literature continues to explore diverse facets of the digital learning landscape, including digital literacy (Holm, 2024), student preferences for online training (Udeogalanya, 2022), learning environments (Yustika & Iswati, 2020), self-directed learning and self-efficacy (Kara, 2022; Hamann et al., 2021; Aslan, 2021), and emerging trends and educator-learner challenges (Dumbuya, 2025). Other studies have focused on aligning student learning styles and cultural backgrounds with e-learning requirements (Philemon et al., 2024). At an institutional level, regulatory bodies such as the National E-Learning Centre (NELC), established by SDAIA (2024), play a vital role in overseeing and enhancing educational quality. Finally, the integration of advanced technologies has intensified critical concerns regarding data privacy and security on digital platforms (Almaiah et al., 2020).

3. Analysis of E-Learning Issues

In this section, e-learning challenges are classified, and technical issues are analyzed in detail.

3.1. Classification of General E-Learning Issues

Based on survey results, expert consultations, and brainstorming sessions, e-learning challenges were classified into five distinct categories, as illustrated in Table 1. This study subsequently focuses on analyzing the first sub-class technical problems using the K-Means clustering algorithm.

3.1.1. Technical Problems

These issues primarily stem from communication infrastructure limitations, resulting in poor service quality. Specifically, **117 survey respondents** confirmed that inadequate service capabilities hinder them from fully leveraging e-learning benefits. Furthermore, existing software platforms (such as Zoom and Moodle) fail to comprehensively support all educational processes such as cognitive retention operations and may not be suitable for every field of study. Application and system security represent another major concern. Additionally, a lack of adequate training for both novice instructors and students pose a significant barrier, intersecting with broader challenges such as funding and logistical constraints.

3.1.2. Logistical Problems

Logistical challenges encompass educational organization, regulations, legal frameworks, training programs, and funding.

3.1.3. Environmental Challenges

Environmental factors relate both to student residency (e.g., remote or urban areas) and external conditions, such as weather (e.g., high temperatures and dust), which can negatively impact e-learning equipment.

3.1.4. Educational Policies

These challenges relate to national objectives and strategic orientations, which directly impact curricula and assessment methodologies.

3.1.5. E-Learning Procedures

The final category involves e-learning procedures, which encompass content presentation, design, learning objectives, and the ultimate educational outcomes. Due to the inherent complexity of these procedures, dedicated further research is required.

3.2. Analysis of Technical Problems

Data was collected using a questionnaire administered to a sample of **117 students** from various faculties at **Omdurman Islamic University**. The questionnaire covered several key topics, including the need for training, security concerns, whether current e-learning platforms meet user expectations, and the availability of internet services. During data preprocessing, necessary categorical features were converted into numerical formats as showed in figure 1. Subsequently, the clustering algorithm was configured with default parameters, except for setting the number of clusters to 5.

Table 1: Demonstration the E-Learing Issues classification

Technical problem	logistic problem	Environment	Education policies	E-learning procedure
- Applications Software. - Infrastructure. - Security. - Training.	- Funding. - Training. - Managements.	Student environment. - Weather	-Orientation of statehood.	- presentation. - Design. - Goals. - Process output.



Figure 1: Data processing stage

3.2.1. E-Learning Application Training

The K-Means clustering algorithm was applied to group the questionnaire responses concerning whether e-learning requires specialized training. The most frequent response was "strongly agree" (accounting for 36%), which indicates that a significant portion of respondents perceives little need for special training. Table 2 and Figure 2 illustrate these results. Notably, the model execution time to build was 0.02 seconds.

Table 2: K-Means Clustering Results

Attribute	Cluster#				
	Strongly disagree	**disagree**	**Neutrally**	**Agree**	**Strongly agree**
The internet service is good and helps spread e-learning	**57%**	26%	0	10%	7%
Internet service costs are possible and available.	34%	**40%**	14%	9%	3%
The applications and programs used in e-learning need further modification to meet the demands of learners.	4%	11%	1%	32%	**52%**
E-learning does not require special training.	15%	13%	9%	27%	**36%**

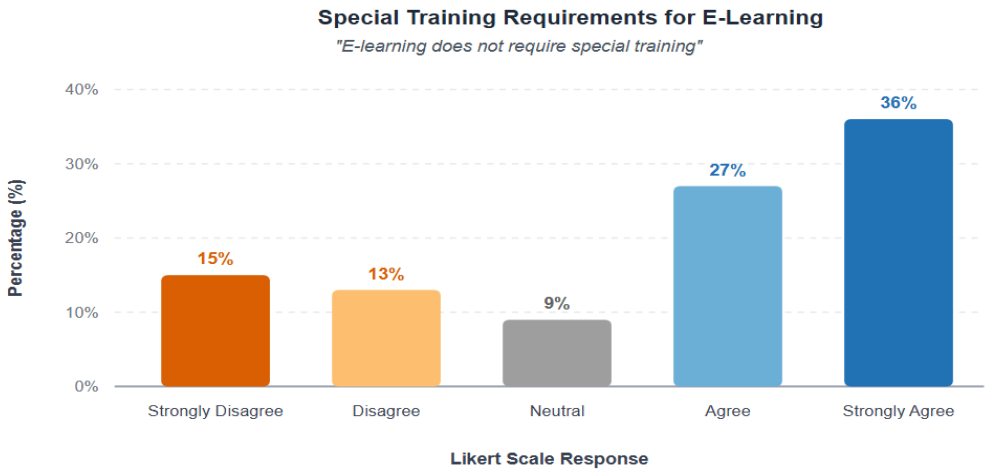


Figure 2: The Training Needs

3.2.2. E-Learning Application:

The K-Means clustering algorithm was similarly applied to analyze responses regarding whether e-learning applications and programs require further modification to meet learners' demands. A significant majority of respondents (84%) selected "Agree," indicating a strong consensus that these platforms need enhancement. Figure 3 illustrates these results. Although most e-learning tools and applications are freely available as open-source software, the findings highlight an ongoing need for technical refinement to better serve educational purposes.

3.2.3. Internet Service:

The K-Means clustering algorithm was applied to analyze responses concerning whether internet service is reliable and supports the expansion of e-learning. The predominant response was "strongly disagree" (accounting for **57%**), indicating substantial weaknesses in service quality. This is further reinforced by a cumulative disagreement rate of **83%**, whereas only a small fraction of students held a positive view (**10%** "agree" and **7%** "strongly agree"). Figure 4 illustrates these findings.

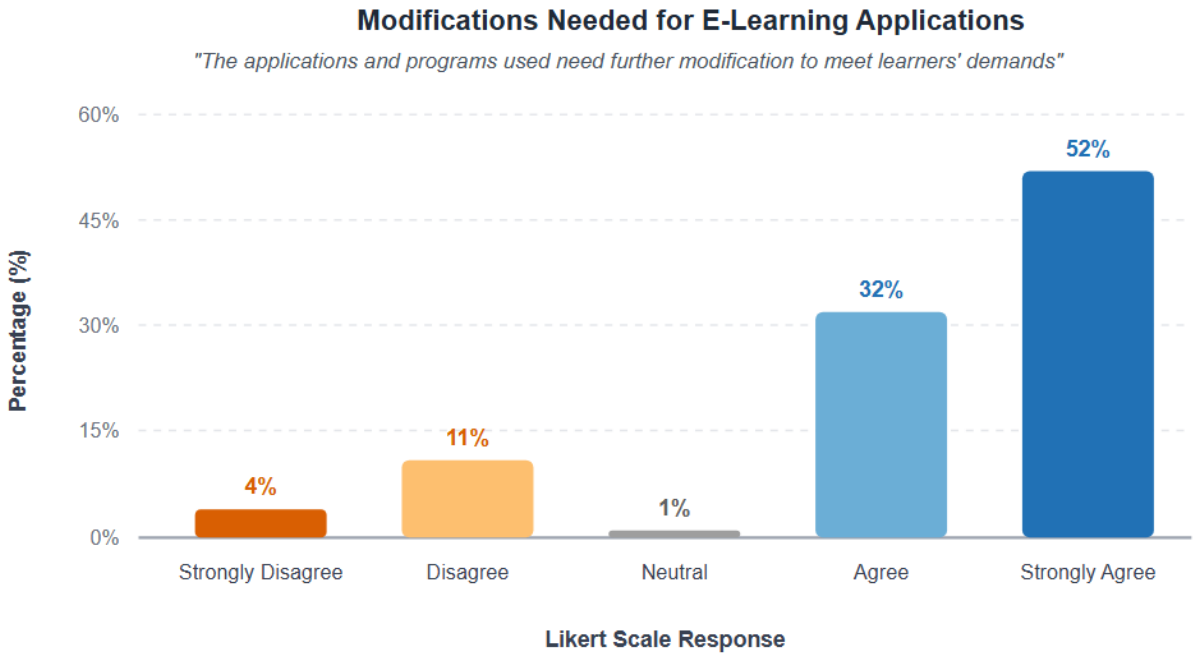


Figure 3: The needs Modification of application

Furthermore, regarding affordability, respondents indicated that internet costs are burdensome, with **74%** expressing disagreement with the statement that service costs are reasonable and accessible. Figure 5 displays the graphical representation of this result. Overall, the findings suggest that the current limitations in both internet quality and affordability hinder the widespread adoption of e-learning, as summarized in Table 4.

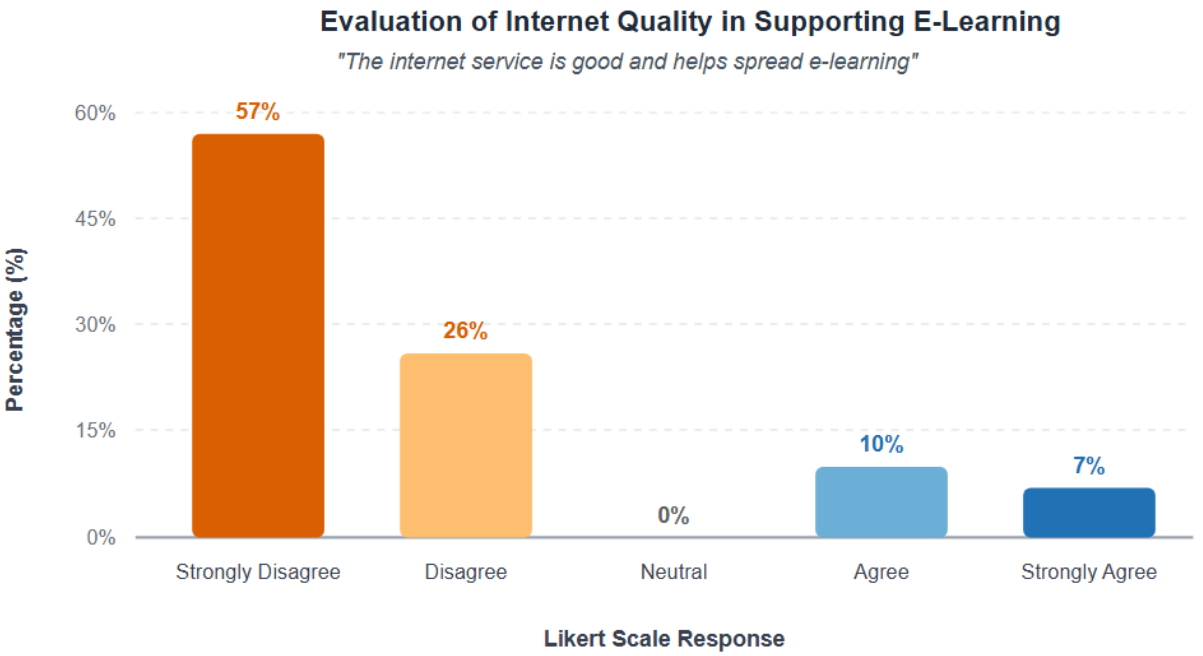


Figure 4: The effectiveness of Internet Service quality

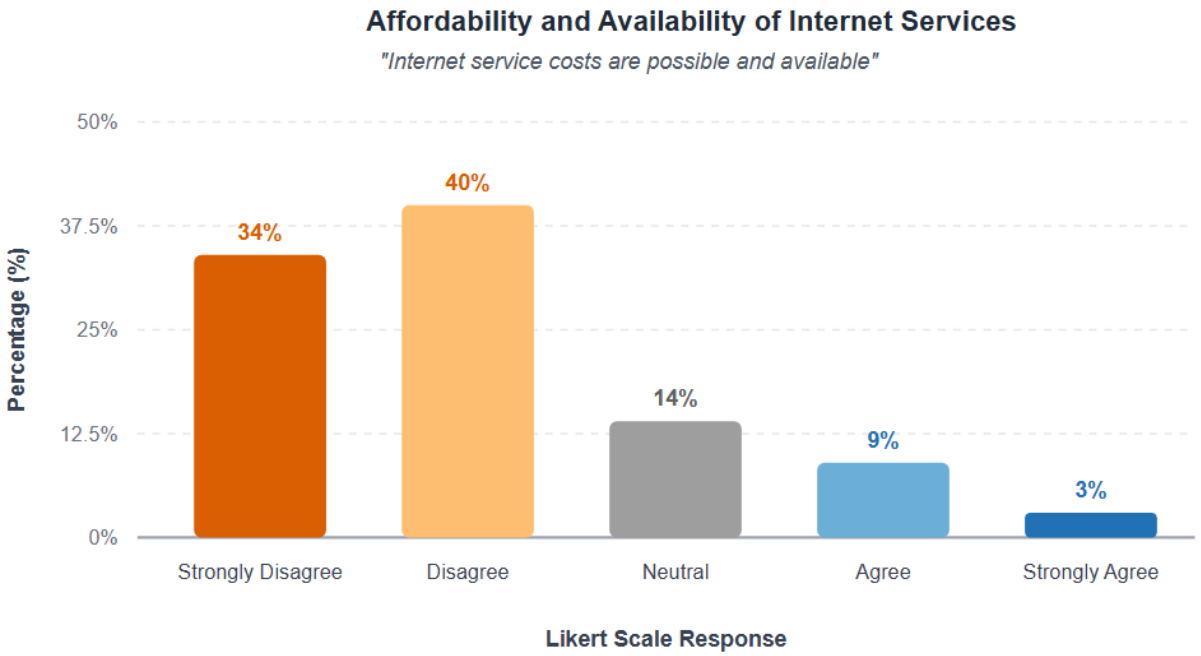


Figure 5: The effectiveness of Internet Service cost

4. Finding or Results:

- Based on the K-Means analysis, the most significant e-learning challenges in Sudanese universities are internet service quality and cost.
- Proficient students felt less need for special application training, whereas they heavily emphasized the need to develop new software supporting all stages of e-learning.
- Less proficient students expressed a strong need for application training alongside the development of comprehensive software platforms.
- Practical components of applied faculties are difficult to execute using current e-learning applications.
- Students strongly expressed the need for enhanced security measures within e-learning services.
- Technical sub-problems are prioritized by student opinion as follows **Internet services (cost and quality), Security, E-learning application support, and Training.**
- Although this study focused exclusively on student perspectives without surveying instructors, parallel studies confirm similar findings.

5. Future Work:

- Expand questionnaires to include specialized or government universities, as well as students with varying technical proficiency levels, to provide a more comprehensive national status report.
- Mitigate internet service limitations by designing resilient technologies that support 24/7 availability, or by partnering with professional service providers to guarantee secure service delivery.
- Conduct deeper software engineering analyses to develop native applications that fully satisfy student requirements.

6. Conclusion

This paper examined e-learning challenges in Sudanese universities from a student-centric perspective. While prior studies primarily concentrated on application limitations or emergency obstacles during the COVID-19 pandemic, this work classified challenges and applied the K-Means clustering algorithm to prioritize technical hurdles based on student feedback. The results demonstrate that technical problems rank in order of priority as: internet services (cost and quality), security, support for e-learning applications, and training. Resolving these foundational bottlenecks is essential for Sudanese higher education institutions to successfully harvest the benefits of e-learning.

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