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Adaptive E-Learning: A systematic review of interactive and flexible learning aligned with student styles

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Abstract

The development of digital technology and the popularity of the internet have made e-learning an increasingly popular learning method to support the dissemination of knowledge in interactive e-learning systems. However, currently, multimedia content-based e-learning systems are still under-explored, and most e-learning system models are not yet adaptive. On the other hand, each student has a different learning style when interacting with the content presented to them. The challenges faced if adaptive e-learning is not implemented properly can lead to poor learning outcomes. In this study, a systematic literature review was conducted with the PRISMA framework to study adaptive e-learning. From this study, 6 potential literatures were obtained from 193 literatures in the initial search regarding the implementation of adaptive e-learning systems that can answer global challenges in the future. The main finding of this study is that adaptive e-learning is able to overcome educational gaps in the future because students are increasingly dependent on digital learning systems worldwide. Ease of internet access plays a major role in the emergence of a lifelong learning system that can support students' learning styles. The results of this study can be the basis for further research in detecting students' learning styles as a basis for developing learning materials to support distance learning.

Keywords: *Adaptive electronic learning, E-learning, Interactive and flexible learning, Learning styles, Systematic literature review*

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1. Introduction

The development of digital technology and the popularity of the internet have made e-learning an increasingly popular electronic learning method, e-learning refers to the delivery and access of multimedia-based learning materials electronically (Alnasyan, Basheri and Alassafi, 2024). The use of e-learning has increased rapidly in recent decades, driven by factors such as the recent pandemic (Dong, 2024). E-learning is very effective in improving knowledge and skills in educational environments (Jin and Kim, 2024). E-learning is not only used in higher education, but also in public administration and the corporate sector (Dong, 2024). Currently, electronic learning systems based on multimedia content are still under-explored, and most e-learning system models are not yet adaptive (Rahman et al., 2024). On the other hand, each student has a different learning style when interacting with the content presented to them, so an adaptive e-learning system is needed according to each student's learning style. The challenges faced if adaptive e-learning is not implemented properly can reduce student engagement, resulting in poor learning outcomes (Mwambe, 2024). Therefore, the study was conducted using the systematic literature review (SLR) method to study the application of adaptive e-learning as an interactive and flexible learning system according to students' learning styles.

2. Literature review

2.1. Students' Learning Styles

Understanding learning styles is the first step to achieving maximum learning results, it is very important in the learning process. The success of student learning is a function of both external environmental factors and internal cognitive processes, such as the student's ability to actively engage with and make sense of information. The appropriate learning style can improve student academic achievement (Rahmawati & Gumiandari, 2021). To enhance the learning process, instructional strategies should be aligned with learners' individual learning preferences and abilities. The use of various learning methods not only makes the learning process more interesting, but also allows students to process information in a way that suits their learning style, thereby improving students' ability to analyze and understand lecture material (Rahmawati and Gumiandari, 2021; Putra and Yuniarti, 2022). It can be concluded that understanding learning styles is a strategy to improve achievement.

2.2. The Technology Interactive and Flexible Learning System

Technological developments offer greater flexibility and inclusivity. Thats can help make it easier to understand and remember learning materials (Safira & Nahdi, 2024). The use of learning media in formal and non-formal education can increase the efficiency of resource management, reduce operational costs, and expand access to education. Students not only gain knowledge, but also the skills needed in the digital era

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(Nababa, Sasi and Permatasari., 2023). Adaptive technology is designed to facilitate learning experiences that are tailored to individual needs, so that they can access learning materials according to their level of understanding (Raj and Renumol., 2021). Learning media supported by adaptive learning methods using interactive and adaptive media offers an approach according to individual learning styles, so that students' abilities can be improved according to their learning styles through the delivery of more interesting materials, so that they are more active and do not feel bored in the learning process (Mwambe, 2024; Sa'diyah, 2022). It can be concluded that adaptive learning can support the implementation of interactive digital learning that can be adjusted to individual learning styles.

3. Method

Research on the application of adaptive e-learning as an interactive and flexible learning system according to students' learning styles can be done with a systematic literature review (SLR) with the PRISMA framework. This research will be focused on a model that describes the level of interactivity and flexibility of the application of adaptive e-learning according to students' learning styles. This aims to be able to implement an adaptive e-learning system that can support future frameworks. There are two research questions that are determined to be the direction of this study, namely:

RQ1. What factors influence the success of the application of adaptive e-learning as an interactive and flexible learning system?

RQ2. What is the impact of the application of adaptive e-learning on students' learning styles?

From the research questions that have been determined, a literature search was carried out by forming a search keyword that combines the keywords "Adaptive e-learning", "Interactive and flexible learning system" and "Students' learning styles". The existing keywords are formed based on the PRISMA framework. The literature search was conducted in Sciencedirect and focused on the period of 2024. This is based on the recency of existing research. The search was conducted using Boolean AND on keywords to make the search process more accurate. Furthermore, filtering was carried out by looking at the relevance of the title and abstract to the research question, then an assessment was carried out using predetermined points, and finally an in-depth review of the most relevant literature was carried out.

4. Findings and discussion

This section discusses the search and screening of literature as well as the synthesis or in-depth review of the literature on the application of adaptive e-learning as an interactive and flexible learning system according to students' learning styles based on

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PRISMA framework. The literature search was carried out by searching for literature available in one digital library, namely Sciencedirect. The selection of this source is because Sciencedirect is a database containing a collection of quality full-text documents that have been reviewed by Elsevier's peer-review, while Elsevier itself is ranked 1st in Scilit in 2024 (Scilit, 2024). From the initial search results, 193 literatures were found that have the potential to be references in the study. The literature that has the potential to be a reference was subjected to initial screening, namely by applying the inclusion and exclusion criteria based on PRISMA framework. (Table 1).

***Table 1**. Inclusion and exclusion criteria*

Inclusion Criteria	Exclusion Criteria
• Journals from sciencedirect	• Journal conference / proceedings / e-book / case study / conceptual / book chapter
• Journal type: literature review	• Non-English language journals
• Journals related to the implementation of adaptive e-learning according to students' learning styles	• Journals that are not from sciencedirect
• Journals that discuss interactive and flexible learning systems in the implementation of adaptive e-learning	
• Journals that discuss interactive and flexible learning systems according to students' learning styles	
• English-language journals	
• Journals published in 2024	

The initial screening that has been done, obtained 31 literatures that can be used as references and can be filtered in the next stage by looking at the relevance of the title and abstract with the research question that has been made previously. From the screening, 15 literatures were found that can be used as references and can be assessed in the next stage. (Table 2).

***Table 2**. Screening results with title and abstract relevance checks*

Keyword			2024
First	**Second**	**Third**	**Sciencedirect**
Adaptive e-learning	Interactive learning system	Students' learning styles	9
	Flexible learning system		6
Total			

Then undergoes final screening by conducting an in-depth review. Literature that successfully passes the final screening stage will become reference literature in this study. Before conducting an in-depth review, an assessment or evaluation of the literature is carried out. In the assessment process, there are several assessment points that are set. (Table 3).

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***Table 3**. Literature assessment points*

No	Assessment Points
1	The journal discusses the factors that influence the success of implementing adaptive e-learning as an interactive learning system (P1) (Score 2)
2	The journal discusses the factors that influence the success of implementing adaptive e-learning as a flexible learning system (P2) (Score 2)
3	The journal discusses the impact of implementing adaptive e-learning on students' learning styles (P3) (Score 2)

There are 3 assessment points obtained from the RQ derivative. There is a weight value for each assessment point, as explained below:

Score 2: there is sufficient discussion of the related assessment point

Score 1: there is little discussion of the related assessment point

Score 0: there is no discussion of the related assessment point

At the assessment stage, only literature with a minimum value of 3 and a maximum of 6 is eligible to be used as reference literature in this study, with the following information:

1. Minimum Score (3): in the literature being assessed, at least 1 assessment point is worth 2, and 1 assessment point is worth 0.
2. Maximum Score (6): in the literature being assessed, 3 assessment points are obtained with a total value of 2.

This assessment process found that there were 6 literatures that were used as references in the study, for further in-depth review. The detailed assessment results. (Table 4).

***Table 4.** Literature assessment results*

No	Reference	P1	P2	P3	Total
1	Alnasyan et al., 2024	2	2	2	6
2	Qazi, 2024	2	2	1	5
3	Dong, 2024	2	2	1	5
4	Karanth et al., 2024	2	2	2	6
5	Jin & Kim, 2024	2	1	2	5
6	Li, 2024	1	2	2	5

The results of the screening and assessment of the literature will then be synthesized or reviewed in depth from 6 potential literatures. The discussion includes factors that influence the success of implementing adaptive e-learning as an interactive and flexible learning system and the impact of implementing adaptive e-learning on students' learning styles.

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4.1. Factors influencing the success of implementing adaptive e-learning as an interactive and flexible learning system

Advances in Artificial Intelligence (AI) and the increasing volume of online educational data have played a significant role in predicting the success of adaptive e-learning implementation (Karanth, Abu Arqub and Dolce, 2024; Alnasyan, Basheri and Alassafi, 2024; Qazi, 2024). Adaptive e-learning can realize interactive learning and support future frameworks (Dong, 2024). Massive Open Online Courses (MOOC) and Learning Management Systems (LMS) are flexible learning tools for students (Alnasyan et al., 2024). Adaptive e-learning is also supported by virtual classes and webinars, this also facilitates distance education and creates an interactive learning environment for students (Karanth et al., 2024).

4.2. The impact of implementing adaptive e-learning on students' learning styles

Adaptive e-learning is needed to help students improve their performance, such as helping students at risk of failure, and preventing dropout rates (Alnasyan et al., 2024). Adaptive e-learning can increase students' motivation to learn and improve their independent learning abilities according to their respective learning styles with a variety of learning resources and learning media available (Jin & Kim, 2024). Learning styles related to student behavior and activities show that student engagement with their learning environment through overall participation has a significant impact on their success (Alnasyan et al., 2024). The integration of interactive content and multimedia-based learning in adaptive e-learning in education can increase student engagement and understanding because it is based on different learning styles (Karanth et al., 2024). Adaptive e-learning is a new, flexible approach to teaching practical skills to students because it is considered to improve student knowledge, skills, self-confidence, and learning satisfaction (Li, 2024).

4.3. Analysis results and relevance of literature

The main factors that influence the success of implementing adaptive e-learning as an interactive and flexible learning system are the ease of access to adaptive e-learning and the support of technology in adaptive e-learning so that it can answer global challenges that are expected to occur in 2045 (Gligorea et al., 2023). Meanwhile, the impact of the development of Artificial Intelligence (AI), Massive Open Online Courses (MOOC), Learning Management Systems (LMS), virtual classes and webinars on student learning styles, mainly is to support student learning styles and improve their performance in terms of increasing student learning motivation so that their mastery of knowledge and interest in learning is also maximized. MOOC and LMS can be well integrated especially with the help of AI which is currently on the rise (Cabrera et al., 2025).

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5. Conclusion

The phenomenon that multimedia content-based e-learning systems are under-explored, so a study was conducted using the systematic literature review (SLR) method with the PRISMA framework. So that an understanding is obtained from the results of the synthesis or in-depth review of 6 potential literatures from detailed screening and assessment. The relevance of the research to global challenges that are expected to occur in 2045. Students will rely on digital learning systems around the world, especially after the pandemic, adaptive e-learning is considered to be able to overcome educational gaps in the future. Ease of internet access is the main role in the integration of AI-based learning materials or the emergence of a lifelong learning system that can support students' learning styles. This can affect policies and regulations related to learning systems around the world that have given many permits for distance learning practices. Research opportunities that can be carried out in the future include detecting students' learning styles as a basis for developing learning materials to support distance learning.

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