The International Journal of Engineering and Science (IJES)
|| Volume || 13 || Issue || 8 || Pages || PP 70-78 || 2024 ||
ISSN (e): 2319 – 1813 ISSN (p): 2319 – 1805

Intelligent Interface Technologies and Challenges in eLearning: A Systematic Review of Literature

George Kimwomi[1], Kennedy Hadulo[1], Kevin Tole[1]
1. *Institute of Computing and Informatics, Technical University of Mombasa, Kenya*

ABSTRACT
The rapid technological advancements experienced in early 1990s influenced the emergency of eLearning as an alternative to physical classroom education which was slowly adopted by some institutions and learners. The effects of the recent covid-19 pandemic prompted a sudden rise in demand for eLearning which became more acceptable to students, learning institutions and other stakeholders. It is however necessary to ensure that the interaction interfaces of eLearning systems are efficient to support effective learning which require the design of intelligent interaction interfaces. This study aimed to identify intelligent technologies used in interaction design and the challenges associated with the interfaces to enable system developers design effective intelligent interfaces for eLearning. A systematic literature review was done on Google Scholar database supplemented by snowballing for articles published in the period 2019 to 2024 to extract the required information. Some 18 interface technologies and a range of associated interface challenges were identified which could be a pointer to stakeholders to design intelligent user interfaces for effective eLearning.

Key words: intelligent interface technologies, interface challenges, eLearning

Date of Submission: 24-08-2024 Date of acceptance: 03-09-2024

I. Introduction

The concept of eLearning emerged in the 1990s influenced by advancements in technology and the internet to facilitate learning (Brika et al., 2022). It requires appropriate human computer interaction interfaces for learners to gainfully access content and learn as expected. e-Learning is a method of teaching and learning based on electronic technologies which aims to enhance access to training and facilitate innovation in learning(Hasani et al., 2020). Recent challenges posed by the covid-19 pandemic have compelled many learning institutions and students to adopt eLearning as an alternative to classroom learning. Users are however faced with human computer interaction (HCI) challenges such as technical skills or unfriendly learning system interfaces which are hampering learning (Ahmad et al., 2023).

Over time, different approaches have been used to design interaction interfaces harnessing available technologies to enhance user experiences. A survey on these approaches identified different types of interfaces such as context-sensitive user interface, adaptive user interface (AUI), multi-modal user interface, smart user interface and intelligent user interface (IUI) (Gonçalves et al., 2019). Among these approaches, IUI based on artificial intelligence (AI) could be helpful in resolving interaction challenges to enhance eLearning. Gonçalves recommended that an interaction interface design should aim at optimizing productivity by enhancing effectiveness, efficiency and naturalness of human-machine interaction. Interfaces manage user interaction with devices, technologies and software systems to ensure that learning takes place as required. Poor interfaces are therefore a barrier to productivity as users will not be able to interact with the devices, technologies and software systems to carry out tasks are required.

Artificial intelligence (AI) approaches have been employed in interaction design since the 1970s so as to have intelligent interfaces which could adapt to individual user behaviors (Laureano-Cruces et al., 2022). Adoption of the technology requires frequent evaluation to establish associated challenges especially following the increased acceptance of eLearning after the covid-19 disrupted classroom learning to support developers resolve intelligent user interface issues. Students are nowadays versed with digital technologies and could prefer to learn using these platforms in place of the traditional educational classrooms (Yehorchenkov et al., 2023). This survey therefore aims to identify the intelligent interface technologies used in interface design in eLearning systems and the challenges associated with the interfaces to help developers to design efficient interaction interfaces to enhance eLearning.

Background

AI has been incorporated in HCI to design IUIs so as to improve system usability and enhance user experience (UX). A system is described as usable if users are able to use it to perform tasks without problems (Divya et al., 2018). An Intelligent user interface is a human-machine interface which seeks to enhance effectiveness, efficiency, and naturalness of human-machine interaction through reasoning, representation, and acting on models of the task, user, domain, discourse, and media such as natural language, graphics and gestures(Maybury, 1998).

IUI entails using intelligent technologies for input, data presentation, adaptive and personalized user interfaces, interactive data analysis, assistance for complex tasks, and intelligent interfaces for ubiquitous computing, affective computing, wearable computing, recommender systems and human robot interaction (Pan et al., 2016). Systems with IUI constitute features to enhance learning such as mapping, automation, scaffolding, mobility, reporting, and knowledge generation(Rerhaye et al., 2021).

eLearning is one of the application areas of AI to create intelligent user interfaces to personalize learning and improve usability. Automation in learning started with computer aided instruction (CAI) which evolved into intelligent teaching systems (ITS) or intelligent learning systems (ILS) to adapt to different users in the 1970s using AI techniques (Laureano-Cruces et al., 2022).

IUI provides a flexibility which aims to personalize and improve interaction between users and machines(Laureano-Cruces et al., 2022). IUIs are designed to adapt users by storing different models of their behavioral characteristics such as such as device, user model, environment model, task model and interaction model which helps to change the user interface to a specific context (Ross, 2000; Calvary et al., 2003; Sanchez et al., 2017).

The use of IUI in a self-directed learning with data visualization has helped to improve learner performance in regards to setting goals and seeking help (Sun et al., 2023). IUI interfaces can motivate learners to frequently refer to learning material, evaluate themselves, check progress on performance charts and take action to raise their performance. Intelligent interfaces provide a range of tools to support learning such as decision support systems, intelligent help and support systems, intelligent assistants, intelligent tutoring systems (Brdnik et al., 2022).

Various technologies have been used for design of intelligent learning interfaces including games and intelligent agents such as chatbots which help to customize learning, emotion recognition techniques, audiovisual systems, and assistive technologies (Toscano et al., 2019; Dratsiou et al., 2020; Rerhaye et al., 2021). IUIs have successfully been implemented successfully in modern system interfaces such as smart cities, smart homes among many others which are based on Internet-of-Things (IoT) even though there could be having some interface challenges (Gonçalves et al., 2019).

The objective of this review was to identify the technologies which have been used to develop IUIs used in eLearning, and the challenges arising from those technologies. This review sought to answer two research questions: -

1) Which technologies have been used to develop intelligent user interfaces used in eLearning systems?
2) What are the challenges of the intelligent user interfaces used in eLearning?

Relevant literature was sought with Google scholar search engine and snowballing (Wohlin et al., 2022).

II. Related literature

A number of literature review studies had been done on intelligent user interface technologies and their challenges in eLearning as shown in table 1.

Table 1: Interface technologies and challenges from related literature

Author	Selected articles	AI technologies identified	Interface challenges identified
(Machado & Santos, 2023)	23	Image Recognition, Voice Recognition, Text Processing, Affective Computing	Limited in accuracy, accountability for replacing human sign language interpreter with an AI translator, lack sensitivity on privacy, security and safety.
(Brdnik et al., 2022)	211	Computer vision, speech recognition, natural language processing, robotics	Inaccessible or lack of cost-effective IUI evaluation guidelines
(Toscano et al., 2019)	31	Audiovisual techniques: educational games, multimedia and interactive environment, augmented reality; assistive technology	None reported

(Gonçalves et al., 2019)	131	Adaptation rules, machine learning techniques; model-based / architecture; model-driven approach, multi-agent architecture; natural language processing	A combination of specific behavioral characteristics, embedded technologies, heterogeneity of devices, and features can make the user interface invisible for the user.

One study evaluated intelligent technologies used for systems for learners with disabilities and the emerging technologies which could be used (Machado & Santos, 2023). A related study mapped IUIs and evaluated their performance which exposed some challenges (Brdnik et al., 2022). Another review highlighted audiovisual System technologies for universal design in learning (Toscano et al., 2019). The next review sought to find out current trends in the design of IUI used in learning systems (Gonçalves et al., 2019). These studies identified a range of interface technologies and challenges even though they were all focused on specific interests which did not fully the expected range of intelligent user interface technologies and challenges which this study seeks to focus on.

III. Methodology

This study adopted a systematic literature review approach with guidelines by Kitchenham et al to establish the state of research on intelligent user interface technologies and challenges in eLearning (Kitchenham et al., 2009). A preliminary search was done on Google Scholar search engine to select target publications which was followed by snowballing to get additional articles from citations and references of the selected articles.

3.1 Inclusion and exclusion criteria

Publications were included if they met these conditions: published within the last five years (2019 to 2024), must be primary from studies, should be available for full access, search string should be available anywhere in the publication, and must be published in English language. Articles which did not meet these conditions were excluded.

3.2 Search protocol

The Key words “Intelligent User Interface”, “interface challenges”, and “eLearning” were used to create a search string for the search in Google Scholar database. After considering synonyms and other terms associated to the keywords, the following search string was generated and used for the search:

("intelligent user interface" OR "intelligent interface" OR "adaptive Interface" OR "ai interface") AND ("challenges" OR "problems") AND ("eLearning" OR "online learning" OR "web-based learning" OR "virtual learning" OR "smart learning" OR "web-based teaching" OR "virtual education")

3.2 Screening and study selection

The search string was executed in Google Scholar database and the publications retrieved were assessed for eligibility for inclusion using the titles and abstracts of articles. Only articles with titles relating to intelligent user interfaces and eLearning with complete text available were considered at this stage. The complete text of the articles filtered were screened further to determine if they discussed the IUI technologies in eLearning for selection to the review as those which failed the test were dropped. Snowballing was applied to search for additional publications which were not retrieved by the primary search string and the articles identified were screened for relevancy and inclusion to the selection list.

3.4 Data extraction and analysis

The selected publications were read in full to extract data related to the research objectives. The data which related to technologies used in the design of IUIs used in eLearning and the interface challenges arising from those technologies were extracted and recorded in a table for analysis. The table contained columns for the publication author, interface design technologies and interface challenges which reflected the requirements of the research objectives.

IV. Results and analysis

4.1 Selection of publications

Execution of the search string in Google Scholar retrieved a total of 1400 publications. some 1355 articles were removed through the exclusion criteria while another 3 were added through snowballing. A total of 18 articles were eventually selected for the study as shown the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) flow diagram in figure 1

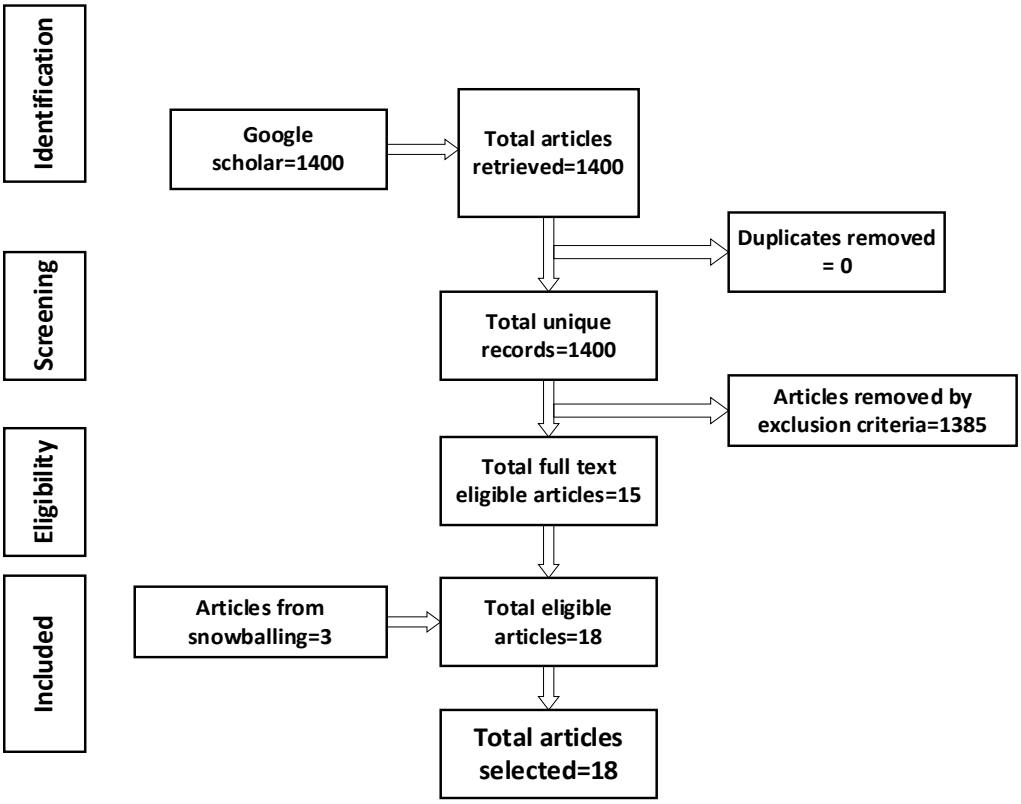

Fig. 1: PRISMA diagram showing the publication Selection process

4.2 Results of data extraction

The data extracted from the selected publications was presented in a table containing details of (i)the author and publication year; (ii) AI interaction technologies identified in the publication; and (iii) interface challenges reported in the publication. All the selected publications reported at least one or more interaction technologies used in interface design while six publications did not report any interface challenges associated with the interaction design technologies used as shown in table 2.

Table 2: Results of data extraction

Author	AI interaction technologies used	Challenges
(Toscano et al., 2019), (Alzahrani, 2020)	Augmented reality	Privacy issues as user emotions and physiological states exposed, information and cognitive overload, lacking experience in using the technology, resistance from teachers, complex technology, costly technology, connectivity problems.
(Sun et al., 2023)	Visualization	Not reported
(Laureano-Cruces et al., 2022)	Virtual avatars	• Focused on incentives instead of the curriculum and learning objectives are met. • Focused on the users' freedom to access the learning topic; but since they are not experts in the field and don't know what they need to learn, it can lead them down tired and wrong paths. • Difficulty in managing the learner
(Yehorchenkov et al., 2023)	Chatbots "Digital Professor"	Not reported
(Helldin et al., 2019)	Interactive data visualization, computer vision, speech processing and machine learning	Threat to Privacy as anyone wearing a Google glass could detect user emotions and physiological states during interaction.
(Machado & Santos, 2023)	Image Recognition, Voice Recognition, Text Processing, Affective Computing	Limited in accuracy, accountability for replacing human sign language interpreter with an AI translator, sensitivity on privacy, security and safety.
(Gonçalves et al., 2019)	Adaptation rules, machine learning, natural language processing	Contemporary Systems present specific behavioral characteristics, heterogeneity of devices, embedded technologies, or other features which if combined may cause interfaces to be invisible to users
(Pradana et al., 2023)	Natural language processing (NLP) / chatbot like - Generative Pre-trained Transformer (chatGPT),	• Lack of guarantee on precision and reliability of AI-generated answers • Fear of replacing teachers with AI. • Moral and legal ramifications of deploying AI in education.

		• Ethical and legal consideration challenges
(Hyland, 2023)	Large language models (LLM) like chatGPT (from OpenAI) and Bard Tool (from Google)	• Regulating super intelligent AI interfaces on ethical issues. • Scary of AI chatbots becoming more intelligent than humans • AI chatbots could be exploited for malicious gains
(Gao, 2022)	Assistive typing techniques	Challenge in translating high-dimensional, continuous user input into desired actions
(Tapalova & Zhiyenbayeva, 2022)	• Virtual reality, • Online gamification for the development skills. • Natural language processing • Audiovisual techniques • Chatbots	• Social and ethical concerns workplaces and public services. • Data security and confidentiality • The impact of virtual assistants on assessments. • Concern on technology replacing human capabilities • Regulations on use of AI • Concerns on the misuse or unintended consequences of AI
(Stirenko, 2020)	• Gamification with augmented reality	• Not reported
(Kouveliotis & Mansuri, 2022)	• Robotics such as Alexa robot	• Robots not able to interact socially like humans • They cannot listen to social problems or solve them
(Louis & ElAzab, 2023)	• Text recognition technology • Semantic analysis • Simulation games • Robots	• Robots and learners cannot communicate and inspire each other like teachers and learners. • Machines cannot communicate with students as humans can. • the right to safe and secure digital spaces is threatened.
(W. Zhang, 2023)	• Virtual reality	• Not reported
(K. Zhang & Aslan, 2021)	• Intelligent agents	• Not reported
(Gligorea et al., 2023)	Chatbots, social bots, Generative bots, Image recognition	• effectiveness depended on quality of content hence cannot replace instructors.

4.3 Classification of interface technologies and challenges

The interface technologies identified from the study were classified by their publication so as to have a clear list of the technologies and their challenges. The classification enlisted 20 interface design technologies with a range of specific interface challenges as shown in table 3.

Table 3: Classification of interface technologies and challenges by publication

Ser.	Interface technology	Interface Challenge	Number of publications
1	Augmented reality	Privacy issues as user emotions and physiological states exposed, Information and cognitive overload, lacking experience in using the technology, resistance from teachers, complexity, costly technology, connectivity problems	3 (Toscano et al., 2019; (Alzahrani, 2020); (Helldin et al., 2019)
2	Visualization	Privacy and security	(Sun et al., 2023); (Helldin et al., 2019)
2	Virtual avatars	• Focused on incentives instead of the curriculum and learning objectives are met. • Focused on the freedom of users to access learning content which can waste their time and mislead them since they are not experts in the field may not know what they need to learn. • Difficulty in learner management	1 (Laureano-Cruces et al., 2022)
3	Natural language processing (NLP)/ Large language models (LLM)/ Chatbots / Social bots/Generative bots	• Could make the user interface to be invisible to users • Lack of guarantee on precision and reliability of AI-generated answers • Impact on the workplace • Concerns about technology replacing human capabilities or teachers • Social, ethical, security, moral and legal issues. • lack of or limited regulations on use of AI • Impact of virtual assistants on assessments. • Data security and confidentiality • Regulation of super intelligent AI interfaces • Scary dangers of AI chatbots becoming more intelligent than humans • AI chatbots could be exploited for malicious gains; misuse or unintended consequences of AI • Effectiveness depend on quality of content hence cannot replace instructors.	4 (Yehorchenkov et al., 2023; Gonçalves et al., 2019; Hyland, 2023; Tapalova & Zhiyenbayeva, 2022); (Gligorea et al., 2023)
4	Computer vision	Privacy issues during interactions.	1

			(Helldin et al., 2019)
5	speech processing	Not reported	1 (Helldin et al., 2019))
7	Image Recognition	• Limited in accuracy • Accountability for replacing human interpreter with an AI translator • Sensitivity on privacy, security and safety	1 (Machado & Santos, 2023)
7	Voice Recognition	• Limited in accuracy, accountability • Sensitivity on privacy, security and safety.	1 (Machado & Santos, 2023)
8	Text Processing	• Limited in accuracy, accountability • Sensitivity on privacy, security and safety.	1 (Machado & Santos, 2023)
9	Affective computing	• Limited in accuracy, accountability • Sensitivity on privacy, security and safety.	1 (Machado & Santos, 2023)
10	Adaptation rules	Invisibility of user interface	1 (Gonçalves et al., 2019)
11	Machine learning	Invisibility of user interface	1 (Gonçalves et al., 2019)
12	Assistive typing	Challenge in translating high-dimensional, continuous user input into the desired actions	1 (Gao, 2022)
13	Virtual reality	• Social and ethical concerns such automation of workplaces and public services. • Data privacy, security and confidentiality • the impact of virtual assistants on assessments. • Impact of AI on the workplace, and concerns about techno replacing human capabilities • Lack of regulations on use of AI • Misuse or unintended consequences of AI	2 (Tapalova & Zhiyenbayeva, 2022; Zhang, 2023)
14	Gamification	• Social and ethical issues on privacy, security, and the impact of virtual assistants on assessments. • Impact of AI and robotics on the workplace, and concerns about technology replacing human capabilities • Lack of regulations on use of AI • Misuse or unintended consequences of AI • Limited intelligence to make judgement compared to human • the right to safe and secure digital spaces is threatened.	3 (Tapalova & Zhiyenbayeva, 2022; Stirenko, 2020); Louis & ElAzab, 2023)
15	Robotics such as Alexa robot	• They cannot interact socially and solve problems like human • Interaction of robots and learners cannot communicate and inspire each other according to their own knowledge like teachers and learners. • Machines only judge students' input and master students' learning situation, which produces wrong information based on machine intelligence‖, ignoring the real situation. • The right to safe and secure digital spaces is threatened.	2 (Kouveliotis & Mansuri, 2022; Louis & ElAzab, 2023)
16	Text recognition	• Limited intelligence of machines to make accurate judgement • the right to safe and secure digital spaces are threatened.	1 (Louis & ElAzab, 2023)
17	Semantic analysis	• Limited intelligence of machines to make accurate judgement • the right to safe and secure digital spaces are threatened.	1 (Louis & ElAzab, 2023)
18	Intelligent agents	Not reported	1 (K. Zhang & Aslan, 2021)

V. Discussion

5.1 Interface technologies in eLearning

A total of 18 interface technologies were identified from the publications selected with a range of interface challenges. The category of natural language processing (NLP)/Large language models (LLM) / chatbots was the most frequently used technology reported in four publications. The majority of these publications were from the most recent studies which reflected that they could be the latest technologies in the market.

The category of augmented reality, visualization and gamification were the next most frequently used technologies with 3 publications each which were also among the most recent studies. Apparently, augmented reality, visualization NLP/LLM/chatbots are the most recent technologies used in interface design for eLearning as reflected by the frequency and date of the publications.

The third most popular interface technologies were robotics and virtual reality which were reported in two publications each. The technologies also appeared in the most recent studies which could also be a reflection that they were among the latest interface technologies in eLearning.

Some of the technologies such as image recognition, voice recognition, text processing, affective computing, assistive typing, text recognition and semantic analysis were reported in single recent publications each which reflected that they were also current technologies in interface design in eLearning.

Other technologies with a single frequency of publication such as computer vision, speech processing, machine learning, adaptation rules and intelligent agents were not reported in the most recent studies and were therefore currently less popular in interface design for eLearning.

5.2 Interface challenges

Most of the studies reported a range of interface challenges associated with the interface design technologies used. The category of NLP, LLM and chatbot technologies which were discussed in the majority and most recent publications had many challenges. These included invisibility of the interface to the user when embedded technologies, behavioral characteristics and heterogeneity of devices were combined. Others included lack of guarantee on precision and reliability, impact of technology at the work place such as replacement of teachers, moral and legal concerns, privacy and security issues. There was also the fear of chatbots becoming more intelligent than humans, and use of AI for malicious intentions.

The augmented reality and visualization technologies which had the second highest frequency and was from the most recent publications was associated with privacy issues during interaction, as well as basing judgement on learners' input while ignoring the real situation which could produce false information. The image recognition, voice recognition, text processing, and affective computing technologies which were also reported in the most publications had challenges on accuracy, accountability for replacing human interpreters with an AI translator, sensitivity on privacy, security and safety.

The robotics technology interfaces could not interact socially with learners like human beings, listen or solve their social problems. The robots and the learners could not communicate and inspire each other as in the case of teachers and learners to share knowledge. The challenge with the assistive typing techniques was on in the translation of high-dimensional and continuous input from users for a desired action. The interfaces were also noted to be limited in intelligence when it comes to judgements and could therefore not judgements like beings.

5.3 Limitations of the study

This study sought to identify intelligent user interface technologies used in eLearning and the challenges associated with those technologies to inform developers in addressing the problems. The process of the review was manual all through and human errors may have occurred as the review took place. However, a cross check of the review works between the authors helped to counter and minimize such kind of errors.

A number of studies which discussed the interface technologies used in eLearning failed to report on the challenges affecting those interfaces. Even though problems such as privacy and security of learners were notable across many of the technologies which reported those challenges, it could not be generalized to the interfaces of technologies where challenges had not been investigated. The technologies were however included in the study as they were not unique from the other technologies so that they could be a subject for future research.

Also, the full text of some publications which appeared to be relevant to the study were restricted from the sources of databases used for this study. Snowballing was used to identify other article which were related to the ones restricted.

VI. Conclusion

This study has presented a systematic literature review on interface technologies used in eLearning and the challenges associated with those interfaces. Natural language processing technologies such as chatGPT from OpenAI and Bard Tool from Google were the most popular interface technologies used in eLearning systems. A wide range of other popular technologies were also used which were reported in the most current publications which included augmented reality and visualization, gamification (or simulation games), robotics and virtual reality among others.

Ethical and privacy issues were the most common interface challenges established across the different technologies. There were other notable challenges found in recent publication such as lack of guarantee on precision and reliability of output from intelligent interfaces, their impact on the workplace the fear of technology replacing human capabilities and the moral and legal ramifications of adopting AI in education.

References

[1]. Ahmad, S., Mohd Noor, A. S., Alwan, A. A., Gulzar, Y., Khan, W. Z., & Reegu, F. A. (2023). eLearning acceptance and adoption challenges in Higher Education. Sustainability, 15(7), 6190.

[2]. Alzahrani, N. M. (2020). Augmented reality: A systematic review of its benefits and challenges in e-learning contexts. Applied Sciences, 10(16), 5660.

[3]. Brdnik, S., Heričko, T., & Šumak, B. (2022). Intelligent user interfaces and their evaluation: A systematic mapping study. Sensors, 22(15), 5830.

[4]. Brika, S. K. M., Chergui, K., Algamdi, A., Musa, A. A., & Zouaghi, R. (2022). E-learning research trends in higher education in light of COVID-19: A bibliometric analysis. Frontiers in Psychology, 12, 762819.

[5]. Calvary, G., Coutaz, J., Thevenin, D., Limbourg, Q., Bouillon, L., & Vanderdonckt, J. (2003). A unifying reference framework for multi-target user interfaces. Interacting with Computers, 15(3), 289–308.

[6]. Divya, K. S., Bhargavi, P., & Jyothi, S. (2018). User Interface Design Issues for Easy and Efficient Human Computer Interaction: An Explanatory Approach. International Journal of Computer Sciences and Engineering Open Access Machine Learning Algorithms in Big Data Analytics, October, 157–166.

[7]. Dratsiou, I., Metaxa, M., Romanopoulou, E., & Bamidis, P. (2020). Exploiting Assistive Technologies for People with Down Syndrome: A Multi-dimensional Impact Evaluation Analysis of Educational Feasibility and Usability. In C. Frasson, P. Bamidis, & P. Vlamos (Eds.), Brain Function Assessment in Learning (Vol. 12462, pp. 148–159). Springer International Publishing. https://doi.org/10.1007/978-3-030-60735-7_16

[8]. Gao, J. (2022). Human-in-the-Loop Reinforcement Learning for Adaptive Assistive Interfaces. https://digicoll.lib.berkeley.edu/record/264381/files/EECS-2022-62.pdf

[9]. Gligorea, I., Cioca, M., Oancea, R., Gorski, A.-T., Gorski, H., & Tudorache, P. (2023). Adaptive learning using artificial intelligence in e-learning: A literature review. Education Sciences, 13(12), 1216.

[10]. Gonçalves, T. G., Kolski, C., De Oliveira, K. M., Travassos, G. H., & Strugeon, E. G.-L. (2019). A systematic literature review on intelligent user interfaces: Preliminary results. Adjunct Proceedings of the 31st Conference on l'Interaction Homme-Machine, 1–8. https://doi.org/10.1145/3366551.3370344

[11]. Hasani, L. M., Sensuse, D. I., & Suryono, R. R. (2020). User-Centered Design of e-Learning User Interfaces: A Survey of the Practices.

[12]. Helldin, T., Bae, J., & Alklind Taylor, A.-S. (2019). Intelligent User Interfaces: Trends and application areas. University of Skövde. https://www.diva-portal.org/smash/record.jsf?pid=diva2:1414074

[13]. Hyland, T. (2023). Educational Responses to Artificial Intelligence (AI) Applications: Problems and Promise. Qeios. https://www.researchgate.net/profile/Terry-Hyland/publication/372891561_Educational_Responses_to_AI_Applications_Problems_and_Promise/links/64cccc03806a9e4e5ce6e7ed/Educational-Responses-to-AI-Applications-Problems-and-Promise.pdf

[14]. Kitchenham, B., Pearl Brereton, O., Budgen, D., Turner, M., Bailey, J., & Linkman, S. (2009). Systematic literature reviews in software engineering – A systematic literature review. Information and Software Technology, 51(1), 7–15. https://doi.org/10.1016/j.infsof.2008.09.009

[15]. Kouveliotis, K., & Mansuri, M. (2022). How Artificial Intelligence Has Changed E-Learning Education in the Meta Era. International Association for Development of the Information Society. https://eric.ed.gov/?id=ED639850

[16]. Laureano-Cruces, A. L., Sánchez-Guerrero, L., Ramírez-Rodríguez, J., & Ramírez-Laureano, E. (2022). Intelligent interfaces: Pedagogical agents and virtual humans. International Journal of Intelligence Science, 12(3), 57–78.

[17]. Louis, M., & ElAzab, M. (2023). Will AI replace Teacher? International Journal of Internet Education, 22(2), 9–21.

[18]. Machado, D. S.-M., & Santos, V. (2023). Inclusive intelligent learning management system framework. International Journal of Automation and Smart Technology, 13(1), 2423–2423.

[19]. Maybury, M. (1998). Intelligent user interfaces: An introduction. Proceedings of the 4th International Conference on Intelligent User Interfaces, 3–4. https://doi.org/10.1145/291080.291081

[20]. Pan, S., Brdiczka, O., Carenini, G., Chau, D., & Kristensson, P. O. (2016). What's Hot in Intelligent User Interfaces. Proceedings of the AAAI Conference on Artificial Intelligence, 30(1). https://ojs.aaai.org/index.php/AAAI/article/view/9868

[21]. Pradana, M., Elisa, H. P., & Syarifuddin, S. (2023). Discussing ChatGPT in education: A literature review and bibliometric analysis. Cogent Education, 10(2), 2243134. https://doi.org/10.1080/2331186X.2023.2243134

[22]. Rerhaye, L., Altun, D., Krauss, C., & Müller, C. (2021). Evaluation Methods for an AI-Supported Learning Management System: Quantifying and Qualifying Added Values for Teaching and Learning. In R. A. Sottilare & J. Schwarz (Eds.), Adaptive Instructional Systems. Design and Evaluation (Vol. 12792, pp. 394–411). Springer International Publishing. https://doi.org/10.1007/978-3-030-77857-6_28

[23]. Ross, E. (2000). Intelligent user interfaces: Survey and research directions. Department of Computer Science, University of Bristol. https://citeseerx.ist.psu.edu/document?repid=rep1&type=pdf&doi=7fedcdaa9cdae5bed24d40dca355c162975c85e5

[24]. Sanchez, C., Cedillo, P., & Bermeo, A. (2017). A systematic mapping study for intelligent user interfaces-IUI. 2017 International Conference on Information Systems and Computer Science (INCISCOS), 361–368. https://ieeexplore.ieee.org/abstract/document/8328132/

[25]. Stirenko, S. (2020). Gamification Approach to the Creation of Virtual Laboratory Works and Educational Courses. https://www.academia.edu/download/91475852/paper6.pdf

[26]. Sun, J. C.-Y., Tsai, H.-E., & Cheng, W. K. R. (2023). Effects of integrating an open learner model with AI-enabled visualization on students' self-regulation strategies usage and behavioral patterns in an online research ethics course. Computers and Education: Artificial Intelligence, 4, 100120. https://doi.org/10.1016/j.caeai.2022.100120

[27]. Tapalova, O., & Zhiyenbayeva, N. (2022). Artificial intelligence in education: AIEd for personalised learning pathways. Electronic Journal of E-Learning, 20(5), 639–653.

[28]. Toscano, R. M., De Souza, H. B. A. M., Da Silva Filho, S. G., Noleto, J. D., & Becker, V. (2019). HCI Methods and Practices for Audiovisual Systems and Their Potential Contribution to Universal Design for Learning: A Systematic Literature Review. In M. Antona & C. Stephanidis (Eds.), Universal Access in Human-Computer Interaction. Theory, Methods and Tools (Vol. 11572, pp. 526–541). Springer International Publishing. https://doi.org/10.1007/978-3-030-23560-4_38

[29]. Wohlin, C., Kalinowski, M., Romero Felizardo, K., & Mendes, E. (2022). Successful combination of database search and snowballing for identification of primary studies in systematic literature studies. Information and Software Technology, 147, 106908. https://doi.org/10.1016/j.infsof.2022.106908

[30]. Xu, D., & Wang, H. (2006). Intelligent agent supported personalization for virtual learning environments. Decision Support Systems, 42(2), 825–843.

[31]. Yehorchenkov, O., Yehorchenkova, N., & Jamecny, L. (2023). "Digital Professor": Interactive Learning with Chatbot Technology (p. 83). https://doi.org/10.1109/SIST58284.2023.10223464
[32]. Zhang, K., & Aslan, A. B. (2021). AI technologies for education: Recent research & future directions. Computers and Education: Artificial Intelligence, 2, 100025.
[33]. Zhang, W. (2023). Virtual Reality-assisted User Interface with Hypertext system for Innovative and Entrepreneurship Education. Computer-Aided Design and Applications, 20(S9), 1–22.