Asian Journal of Distance Education

Artificial Intelligence Applications in Open and Distance Education: A Systematic Review of the Articles (2007-2021)

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Abstract: With the urgent shift to distance learning due to Covid-19 measures, educational institutions around the world have started to adopt e-learning massively. According to many experts, artificial intelligence (AI) may provide both system-wide and pedagogical solutions to the problems which the administrators, educators, and students encounter during e-learning. The purpose of this study was to systematically review articles on AI applications in open and distance education between the years 2007 and 2021 in order to visualize the potential of intelligent educational systems. Thus, 171 selected articles regarding explicit inclusion and exclusion criteria, were analysed in terms of the year/ place of the paper, affiliation of the first author, the method applied, and the journals they published in. Then the research areas of AI applications in distance education were coded iteratively. The results indicated that most of the articles were published after 2018 mainly by Chinese, Spanish, Turkish, American, and Indian authors in computer science and STEM disciplines. Moreover, there is a sharp increase in publishing on this topic, especially during Covid-19 pandemics. Consequently, the analysis resulted in six areas of AI applications in open and distance education: 1. ITSs, 2. Adaptive systems and personalisation, 3. assessment and evaluation, 4. learner analytics, 5. affect recognition, and 6. Virtual learning environments, with 28 subcategories. In summary, our review results that intelligent systems can be effectively used for both system-wide solutions and pedagogical solutions to the problems such as the low level of adaptivity, collaboration, academic achievement, or engagement, and the high level of drop-out that we usually experience in distance learning via the use of adaptive expert systems, intelligent tutors or agents, chatbots, data analytics, and recommender systems.

Keywords: artificial intelligence, distance education, intelligent agents, systematic review, Covid 19

Highlights

What is already known about this topic:

- Artificial intelligence is changing every sector including education.
- There are a few review studies on the applications of intelligent systems in education although AI constitutes a great potential for distance learning.
- The rapid shift to distance education urges the need for finding novel ways of instruction assisted by intelligent systems, especially in disruptive times like Covid 19 pandemics

What this paper contributes:

- This provides the academic community with a unique systematic review of existing academic research on AI applications in open and distance education
- This provides findings of research trends in 15 years on AI applications to visualize the future direction of distance learning
- This enables the decision makers in open and distance education institutions recognize the importance of this research niche and see the potential of AI use in e-learning
- This provides researchers with a review of the field with identification of gaps and future research opportunities.

Implications for theory, practice and/or policy:

- The advantages of intelligent systems over existing educational technology should be highlighted and disseminated.
- The research gaps highlighted in this paper, such as the lack of studies stating how to ensure the sustainability and adoption of these very expensive laborious intelligent technologies in distance education institutions. This can lead to changes in practice and policy.

Published by Asian Society for Open and Distance Education (ASODE), Japan
ISSN 1347-9008 http://www.asianjde.com/

Introduction

According to John McCarthy (2007) artificial intelligence is " a machine that behaves in a way that could be considered intelligent if it was a human being" or "the science and engineering of making intelligent machines" In other words, artificial Intelligence (AI) can be defined that the computer systems who can mimic the actions humans perform such as thinking, learning, problem-solving, planning, reasoning All terms such as machine learning, artificial neural networks, deep learning, expert systems, etc. are summarized under the generic term of artificial intelligence (AI). Many people now see AI as a key component of the industry 4.0, and it has the potential to spark a fourth revolution in education. According to the Horizon Report 2020 Higher Education Edition report, most incoming students had the option to gather an AI assistant by 2027 (Brown, et al., 2020). These AI companions assist the students by providing "oversight, nudging, adaptive mentoring, research assistance, feedback on assignments, and friendly encouragement" (Brown, et al., 2020, p. 36). The most common AI applications in education can be listed as intelligent tutoring systems (ITS), chatbots, recommender systems, automated assessment and grading systems, and support systems. These AI technologies are beneficial for educational administrators, lecturers and learners in terms of profiling learners' prior knowledge, learner styles and learning preferences in order to provide personalised and adaptive learning environment; predicting learners' academic achievement-failure, their course selection etc. using learner analytics; assisting both teachers and students in providing feedback, instruction, and assessment; and providing recommendations to educational administrators about the effectiveness of the teaching and learning process and the system.

Artificial Intelligence applications in education (AIEd) are on the rise and have received a great attention especially during Covid 19 pandemics, through which most of the universities and colleges must swift to distance education. Since this topic constitute a new domain with largely unstudied potential, our study aimed to systematically review AI applications in open and distance education between the years 2007 and 2021. In general, prior work is limited to a subset of a few review studies, which analysed keywords, research trends, opportunities, and challenges of AI applications in education (Zawacki-Richter, et al., 2019; Zhai, 2021; Zhang & Aslan, 2021; Bozkurt, et al., 2021; Hwang, Tu & Tang, 2022; Chen et al., 2020; Kuleto et al., 2021; Paek & Kim, 2021; Tahiru, 2021; Zhai et al., 2021;), an article reviewing AI in language education (Liang et al., 2021) and a paper on the affective intelligent systems in distance education (Aljarrah, et al., 2021). Although some attempts have been made to address this issue, this research niche requires further investigations for the research trends, and the potential of AI applications in education in order to visualize the future direction of distance education.

Literature

According to 'Artificial Intelligence and Life in 2030 - One Hundred Year Study on Artificial Intelligence: Report of the 2015-2016 Study Panel' by Stanford University, eight areas are considered by AI experts to be very important to focus on. These areas are transportation, service robots, healthcare, education, low-income communities, public safety and security, employment and workplace, and entertainment. Especially in the field of education, AI promises development at all levels of education, with opportunities to customize the learning-teaching process (Stone et al., 2016).

'Application of Artificial Intelligence in Education' (AIEd), which brings educational sciences such as education, psychology, neuroscience, linguistics, sociology, and anthropology together with artificial intelligence, has been the subject of academic research for more than 30 years (Luckin et al., 2016). The use of artificial intelligence technologies in educational institutions at many levels, from teaching to evaluation, is becoming more common day by day. For example, artificial intelligence applications such as pedagogical agents, intelligent tutoring systems (ITS), smart learning environments, learning analytics, intelligent learning management systems (ILMS) and adaptive learning systems (Joshi, Rambola, & Churi, 2021) have been welcomed by many educational institutions. In addition, according to the Artificial Intelligence Market report in the USA Education Industry, artificial intelligence in USA

Education is estimated to grow by 47.5% from 2018 to 2022. These statistical predictions indicate that the use and potential of artificial intelligence technologies in educational institutions will become more prominent in the following years.

Furthermore, there are many benefits that AI technologies provide in the field of distance education. For example, these AI tools used in education can improve learners' academic success by providing one-to-one tutoring to students who need extra help to advance in the learning process, providing personalized learning content to support students with specific learning difficulties, and making school systems more affordable for low-income families so they can eliminate the achievement gaps among students. Besides, these artificial intelligence-based technologies can provide teachers with the opportunity to improve their expertise through in-service training, and thanks to their assistance, they can reduce teachers' stress and workload, thus these intelligent tools can protect them from feeling burnt out (Luckin et al., 2016). In summary, AI tools and technologies can work collaboratively with the instructor, supporting the instructor and increasing efficiency and personalization in the learning process; can facilitate administrative tasks; provide students with differentiated and personalized education through adaptive content, curricula and feedback; provide universal access to all students, including the visually and/or hearing impaired; can grade exams and homework; and can also support and teach students outside of the classroom.

On the other hand, there is a limited number of review studies focusing on the use of AI in education in contrast to the great interest in AI technologies and applications. Firstly, Zawacki-Richter et al. (2019) reviewed the articles on AI applications in higher education between 2007 and 2018 and found out four areas of AI applications. They are listed as profiling and prediction, assessment and evaluation, adaptive systems and personalisation, and intelligent tutoring systems. Next, Zhai and his colleagues (2021) applied content analysis of papers between 2010 and 2020 to explore the overall state of AIEd and the research trends of it. As a result of their study, they identified four research trends, namely internet of things (IoT), swarm intelligence, deep learning, and neuroscience. Furthermore, Zhang and Aslan (2021) detected six types of AIEd technology applications in their review of 40 empirical studies (1993-2020) such as chatbots, expert systems, intelligent tutors or agents, machine learning, personalized learning systems or environments, and visualizations. Finally, Bozkurt and his colleagues (2021) systematically reviewed AI studies in education in half a century (1970- 2020) using social network analysis and text mining approaches. Their extensive research suggested five broad research themes for the use of AI in education, namely, adaptive learning and personalization, deep learning and machine learning algorithms for e-learning, educational human-AI interaction, educational use of AI generated data, and AI in higher education.

Consequently, AI technologies can be very effective in all fields of education, especially in distance education because of the great potential of adapting these intelligent systems to e-learning systems. Consequently, this paper intends to build a deeper understanding in AI technologies for distance education, including its current state, potentials, and future directions via systematically reviewing the articles relating this research niche.

Methodology

Research Method and Design

This paper used the method of systematic review, which can be defined "a review of existing research using explicit, accountable, rigorous research methods", in order to reach at a reliable and comprehensive overview of the research on the artificial intelligence applications in open and distance education (Gough, Oliver & Thomas, 2017, p. 2). The aim of reviewing systematically is to answer specific questions based on explicit, rigorous, and accountable methods with previously defined inclusion and exclusion criteria. Consequently, the main purpose of this study is to identify research

trends and patterns of articles on AI applications in open and distance education. Within this context, the methodology of the study was designed to investigate the following research questions (RQ):

- RQ1. What is the distribution of the reviewed studies by year, (2007 – 2021)?
- RQ2. What is the distribution of the studies reviewed by the journals they were published in?
- RQ3. What are the outlines of the reviewed studies (geographically and institutionally distributed)?
- RQ4. What is the distribution of the research methods applied in the reviewed studies?
- RQ5. What are the trend research topics in the field of artificial intelligence applications in open and distance education in 2007- 2021?

In systematic review, the data is then coded and extracted from the sampled studies so as to synthesise the findings (Gough, Oliver & Thomas, 2017). As a result, in this study, 171 selected articles on the topic of artificial intelligence applications in open and distance education were reviewed using explicit, rigorous, and accountable methods.

Sampling and Data Collection

The sampled articles of the research were selected according to a search string (see Table 1) and inclusion criteria by both authors. According to that inclusion criteria, the search was limited to the period from 2007 to until the end of 2021. The year 2007 was chosen as a starting point because *deep learning*, which is able to identify features by itself from input data and learn without memorizing specific knowledge or patterns, was invented by researchers in computer science and cognitive psychology in 2006. After 2006, the so-called 'Third AI Boom' sparked the research niche of AIEd. Also, that year iPhone Siri, an algorithm-based personal assistant, was introduced and became a widespread application among ordinary people.

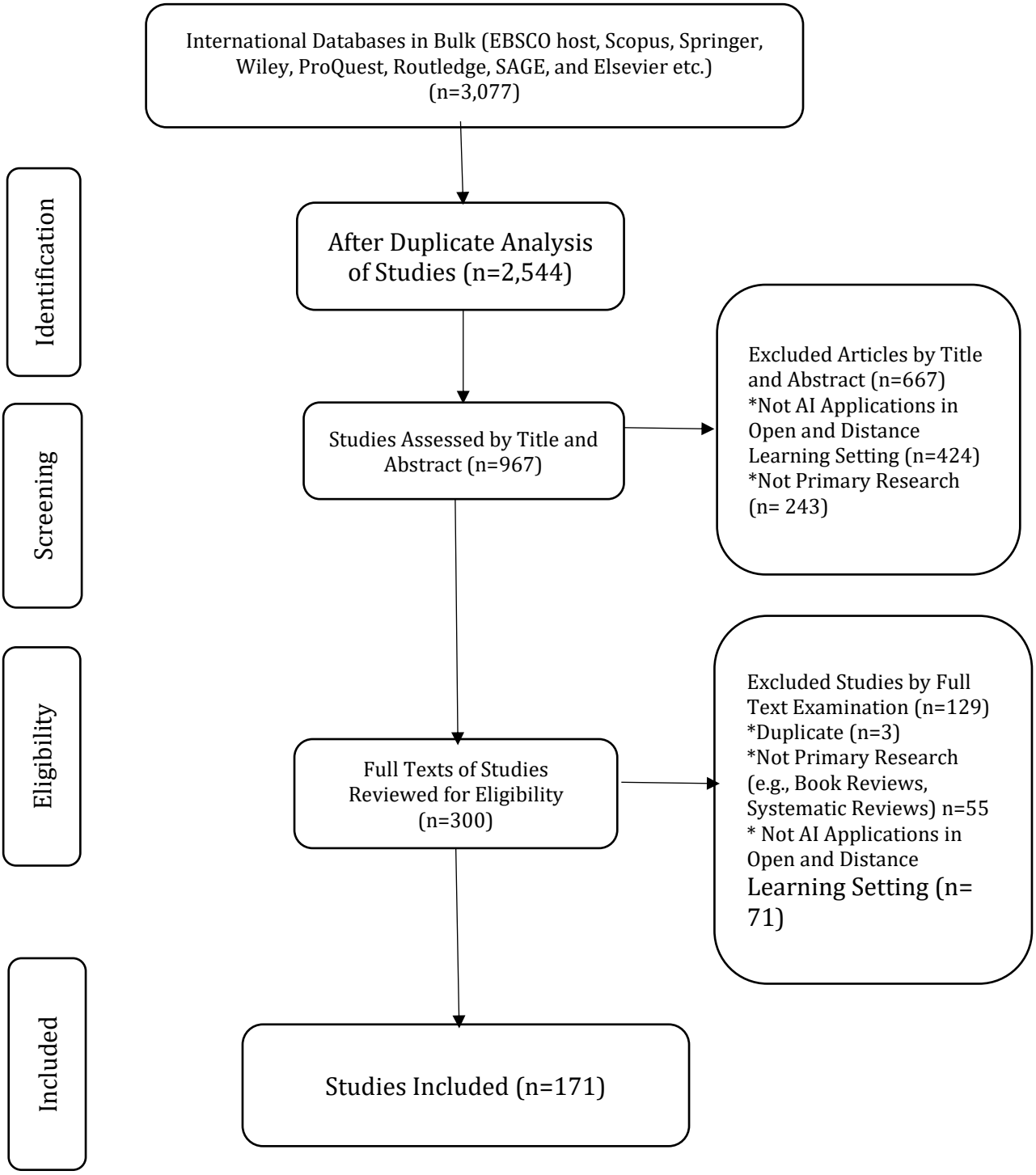
To sift through the articles, several international databases such as EBSCO host, Scopus, Springer, Wiley, ProQuest, Routledge, SAGE, and Elsevier etc. were searched in bulk through Anadolu University Library databases. Furthermore, in the study only the articles in English, which were empirical and primary research on artificial applications in open and distance education were preferred as samples of research.

Table 1. Search String

Topic	*Search Keywords*
Artificial intelligence	"Artificial intelligence" OR "machine learning" OR "intelligent tutoring systems" OR "chat bots" OR "intelligent virtual reality" OR "intelligent support" OR "neural network" OR "intelligent agent"
AND	
Education Mode	*"Distance education" OR "e-learning" OR "blended/hybrid learning" OR "open learning" OR "online learning/teaching"*

Our search for articles to be reviewed returned 3,007 articles from various databases. After eliminating the duplicates, there were 2,544 articles to be reviewed. Then, upon examination of the titles and abstracts, 1,577 of those 2,544 articles were excluded because they were not directly related to the topic of AI applications in open and distance education, and they were not primary research. Furthermore, the remaining 300 articles were reviewed by full text for eligibility, and 129 of them were removed for being duplicates, not being primary research and not being related to the topic of the study. Consequently, after screening and examining articles, a total of 171 articles that met the inclusion criteria were further analysed (see Figure 1).

Figure 1. Flow of the systematic review process (Moher, et al., 2010)



Data Analysis

All the articles examined in this study were coded and analysed by two researchers. For the analysis, the authors applied the content analysis method, which is usually used for textual analyses permitting comparing, contrasting, and categorising the data (Fraenkel & Wallen, 2000). First, a form to record the results of the analysis was created using Microsoft Excel. The categories listed in the form were related to research questions such as the year/place of study, affiliation of the first author, the method applied, and the iterative codes of the reviewed studies. Eventually, they were coded by both writers.

To ensure inter-rater reliability, the sampled articles were reviewed and coded by both authors separately. Then two sets of codes (20 randomly chosen articles) were analysed through SPSS to determine the Cohen Kappa coefficient value, which was found to be 0.72 As Viera and Garrett (2005) stated values between 0.61 and 0.80 indicate optimal agreement between the researchers, the coding of the article in this study can be considered acceptable, with an inter-rater value of 0.72 for Cohen Kappa statistics.

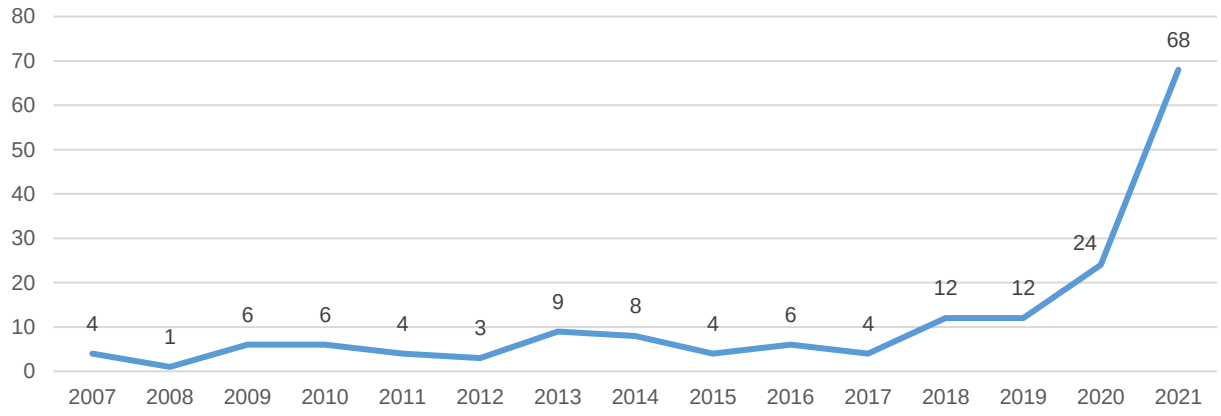
Results

Distribution of the Published Studies in Time

The distribution of studies referring to AI applications in open and distance education by years is shown in Figure 2. It was observed that there was a sharp increase in the number of papers published after 2018 – almost 68 % of the articles were written then. Our time trend analysis shows that AI in distance learning publications will maintain its increasing momentum, particularly towards the end of the second decade. These findings are in line with results reported by other publications on AIEd in the literature (Bozkurt et al., 2021; Paek & Kim, 2021; Zawacki-Richter et al., 2019; Hwang, Tu & Tang, 2022). There are probably several factors supporting this increasing trend, such as the rapid development of AI algorithms like deep learning and machine learning, the accumulation of big data, and other innovative developments like cloud computing, blockchain programming, and 3D technologies.

In addition, the highest number of articles were published in 2021. The reason for this significant increase could be due to the AI rise in education and the mandatory shift to distance learning for Covid 19 pandemics. Additionally, a shortage of human sources – especially in the field of health –, rising educational costs, the need to assist little kids who are not independent distance learners yet, and the need to maintain social distance may have necessitated the development of intelligent educational systems during this global crisis.

Figure 2. Number of Included Articles Per Year (n = 171)



Journals

The articles in our study were found to be published in 102 different journals (see Table 2). The leading journal with 9 articles published on AI applications in distance education is *International Journal of Emerging Technologies in Learning (IJET).* The greatest number of articles going after it (n =8) were published in*, International Journal of Artificial Intelligence in Education,* and *Computers & Education.* They are followed by the journal of *Complexity* (n = 6), and the journals (n = 5); *Knowledge Based Systems*, and *Education and Information Technologies.* These top 6 journals published %23 of articles on AI applications in distance education. Moreover, there were 72 journals that published one article on AI applications in distance education.

Table 2. Number of articles included (n =171) by journals

Rank	Journal	n
1	*International Journal of Emerging Technologies in Learning (IJET)*	9
2	*Computers & Education*	8
	International Journal of Artificial Intelligence in Education	8
3	Complexity	6
	Knowledge- Based Systems	5
4	*Education and Information Technologies*	5
	Interactive Learning Environments	4
5	*International Journal of Web-Based Learning and Teaching Technologies*	4
	Journal of Computing in Higher Education	4
	Turkish Online Journal of Distance Education (TOJDE)	
	International Journal of Distance Education Technologies	3
	Computers in Human Behaviour	3
6	International Journal of Educational Technology in Higher Education	3
	Informatics in Education	3
	Expert Systems with Applications	
	IEEE Access	2
	International Journal of Computers, Communications & Control	2
	Neural Computing and Applications	2
7	Australasian Journal of Educational Technology	2
	Soft Computing	2
	Educational Technology & Society	2
	Journal of Computer-Assisted Learning	2
	Journal of Ambient Intelligence and Humanized Computing	2
	IEEE Transactions on Learning Technologies	2
	The International Journal of Information and Learning Technology	2
	Scientific Programming	2
	Computational Intelligence	2
	Entropy	2
	Sustainability	2
	Education Sciences	2
	Others with one article	2
		72

Countries

Our study results that artificial intelligence in open and distance education research has been conducted in many countries around the world. We analysed the geographical distribution of articles to determine which countries' academicians are more interested and prolific in this research era. For the analysis of the geographical distribution of articles, the country of origin of the first author was taken into account (n = 44 countries), by following previous review studies (Zawacki-Richter, et al., 2019; Hwang, Tu & Tang, 2022). It was seen that 17 countries such as Finland, Thailand, Japan, the Netherlands, Jordan

etc. contributed with one article, whereas more than half of all articles (51 %) came from China, Spain, Turkey, the USA, India, the UK, and Canada (see Table 3). Chinese academics are the first rank with the highest number of articles they published (n = 26), which are followed by their Spanish colleagues (n =14) and Turkish colleagues (n= 13).

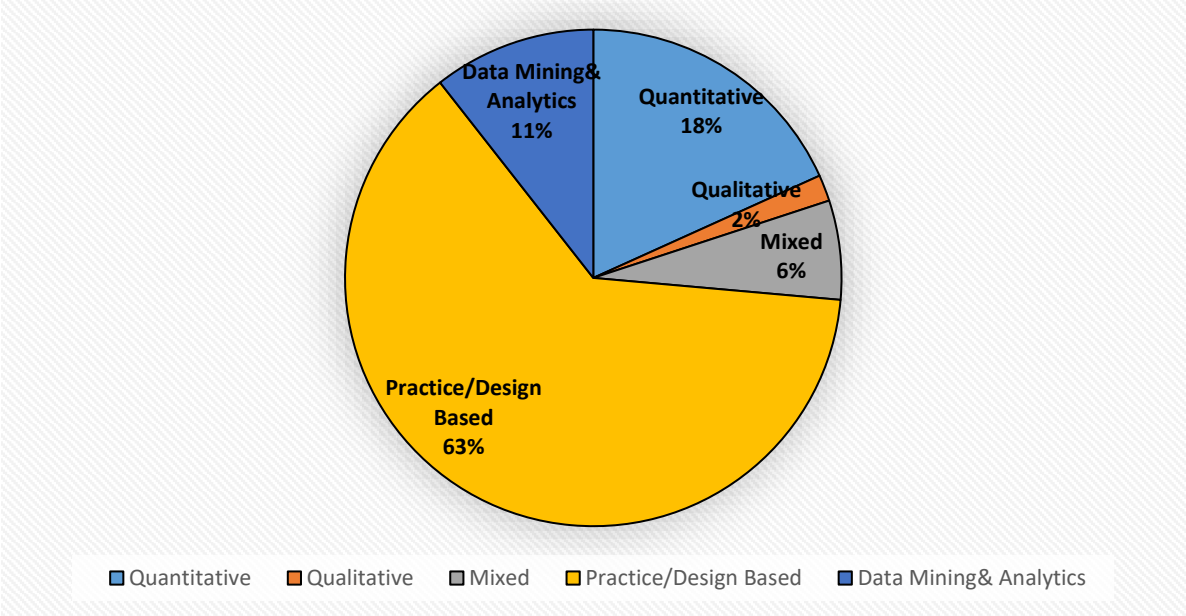
Table 3. Distribution of articles by country and cumulative percentages (n = 171)

Rank	*Country*	*n*	*%*	*Rank*	*Country*	*n*	*%*
				9	Portugal	3	0,73
1	China	26	0,15		Argentina	3	0,75
					France	3	0,77
2	Spain	14	0,23		Serbia	3	0,78
					Australia	3	0,80
3	Turkey	13	0,31		Ecuador	3	0,82
					Saudi	3	0,84
4	The USA	11	0,37		Arabia		
5	India	10	0,43	10	Croatia	2	0,85
					Lithuania	2	0,86
6	The UK	7	0,47		Romania	2	0,87
					Kenya	2	0,88
7	Canada	6	0,51		Kazakhstan	2	0,90
	Greece	6	0,54				
	Taiwan	6	0,58				
8	Morocco	4	0,60				
	Algeria	4	0,62		Others with		
	Iran	4	0,65		one article	17	1.00
	Russia	4	0,67				
	Italy	4	0,69				
	Indonesia	4	0,72				

Methods Used in the Articles

The findings reveal that *practice-based* studies constitute the most employed methodology (n = 108). Such studies may indicate the tendency of designing AI technologies for education in the research era, which would be also favourable in contributing the achievement and sustainability of AIEd (Artificial Intelligence in Education). Furthermore, the second most widely used methodology is *quantitative research* (n = 31). The most used quantitative methods were experimental studies, which try to explore the effectiveness of the intelligent algorithms in learning ang teaching process and/ or the users' reflections about them. Both *data mining and analytics* (n = 18) and *mixed methods* (n = 11) follow as the next most prevalent methodologies used in the articles (see Graph 1). Also, *qualitative studies* constitute the least used type of research methodology (n = 3), which is not surprising because of the nature of research on AI applications. Consequently, these findings are in line with the results reported by Zawacki-Richter et al. (2019).

Graph 1. Percentage of the Methods Used in the Articles (n = 171)



Author Research Disciplines

For institutional distribution analysis of articles, the research disciplines of the first author was taken into consideration (see Table 4). Although 35 researchers' departments were not mentioned in the articles clearly, 58,8 % of the researchers working in departments of Computer Engineering and Information Sciences (n = 36), Computer Sciences and Engineering (n = 30), STEM (n= 20), and Computer Science and STEM (n= 15) contributed by far the greatest. Therefore, it can be inferred that the departments related to computer sciences and STEM are very active in the research era of AI applications. Also, 22 papers were written by first authors with an education background. Moreover, 5 first authors came from the Art, Humanities, and Social Sciences department, and 5 researchers came from the department of Psychology and Intelligent Systems. Consequently, several first authors of the article are specialized at the fields of Information and Communication Sciences (n= 2), and Medicine (n=1).

Table 4. Research Discipline of the First Author (n = 171 articles)

Research Discipline	***n***	***%***
Computer Engineering and Information Sciences	36	21,0
Not mentioned	35	20,4
Computer Sciences and Engineering	30	17,5
STEM	20	11,6
Computer Science and STEM	15	8,7
Education	14	8,1
Art, Humanities and Social Sciences	5	2,9
Psychology and Intelligent Systems	5	2,9
Education Technology	4	2,3
Education and STEM	4	2,3
Information and Communication Sciences	2	1,1
Medicine	1	0,5
Total	171	100

AI applications in open and distance education

Having used Reid's (1995) concept of the student life cycle as a framework, we defined the various applications of AI at the institutional and administrative level of distance education in a broader sense, as well as at the academic teaching and learning level of distance education in a narrower sense. In our study, the AI services mentioned in 63 articles were related to administrative and institutional support services, while 132 articles covered the use of AI tools for academic support services.

In addition, six areas of AI applications in open and distance education were coded with 28 sub-categories in the publications: a) Intelligent tutoring Systems, b) Adaptive Systems and Personalisation, c) Assessment and Evaluation, d) Profiling and Prediction/ Learner Analytics, e) Affect Recognition/ Affect sensitive E-learning, and f) Virtual Learning Environments. While first four of these codes are parallel with Zawacki-Richter and his colleagues' (2019) findings in their study on AI applications in higher education, two new AI applications in distance learning – affect recognition and virtual learning environments – were found in our study (see Table 5).

Table 5. Number of AI Applications in Distance Education Across Studies, Multiple Mentions Possible

AI Applications in Distance Education	**n**
Intelligent Tutoring Systems (Intelligent Language Tutoring systems/ chatbots; Adaptive Intelligent Tutoring Systems; Interoperable Intelligent Tutoring System; virtual assistants; educational agents; teaching course content; student modelling; assisting teachers; smart assistive systems for the visually impaired; facilitating collaboration)	66
Adaptive Systems and Personalisation (providing personalised syllabus; course content; assignments and tests; recommending adaptive learning environment according to learning styles and prior learning; the guided learning mechanism)	42
Profiling and Predictions / Learner Analytics (student modelling; Knowledge Tracing (KT); predicting learners' academic achievement- failure; drop-out and retention; course selection; predicting and clustering behaviour patterns of learners; analysing student collaboration)	42
Assessment and Evaluation (system evaluation and administrative decisions; automated grading; plagiarism detection; remote proctored exams; assessment of student engagement, competencies, and academic integrity; user authentication; assessing learners' prior knowledge and cognitive load)	28
Affect Recognition / Affect Sensitive E-learning (recognizing learners' affective states and academic emotion by analysing head pose, eye gaze, facial expressions, etc.; giving affective feedback)	14
Virtual Learning Environments (3D virtual campus, classroom, labs, etc.; intelligent augmented systems; virtual patient simulator)	6
Total	198

Intelligent Tutoring Systems (ITSs)

Intelligent Tutoring System (ITS), which is a kind of intelligent education system, takes into account the knowledge about what to teach (the subject matter), the way to teach (the learning and teaching scenario), as well as the relevant information about the student being taught (Rosic et al., 2005). With the evaluation of the pedagogical framework of e-learning from computer assisted instruction grounded in behavioural learning theory to cognitive learning theory and teaching paradigm, intelligent tutoring systems have become widespread due to their characteristics from computer science, cognitive psychology, and educational research. Therefore, most of the articles in the review were found to be relating the application of AI as Intelligent Tutoring Systems in open and distance education (n = 66).

The most common terms referring to ITS mentioned in the studies are *intelligent tutoring systems and intelligent agent* (in Rouhani & Mirhosseini, 2015; Rodrigues, João & Vaidya, 2012; Mitchell, 2007);

intelligent distance learning systems (in Latinović & Vasiljević, 2020); *intelligent language tutoring systems*, *chatbots,* and/ or *conversational agents* (in Jia, 2009; Tamayo, et al., 2020; Procter, Lin & Heller, 2018; Lippert, et al., 2020); *adaptive and intelligent educational systems* (in Hafidi & Bensebaa, 2014; Iglesias, et al., 2009;Arguedas & Daradoumis, 2021); *pedagogical agents* (in Ivanović, et al., 2015); or *virtual (teaching) assistant* (in Laeeq & Memon, 2019; Chou, Huang & Lin, 2011).

In the study, 12 articles were relating to adaptive intelligent tutoring systems. These studies aimed to provide adaptive and personalised e-learning environment (Gonzalez, et al., 2013; Iglesias, et al., 2009; González-Castro et al., 2021; Guerrero-Roldán et al., 2021; Oliveira et al., 2021; Troussas, Krouska, & Sgouropoulou, 2021; Vuković et al., 2021) by clustering e-learners according to their skill level and multiple intelligences (Hafidi & Bensebaa, 2014), and their online learning behaviours (Šarić-Grgić, et al., 2020). Clustering distance learners in this way enables the educational authorities and teachers to select, sequence and present course materials, syllabuses, assignments, feedbacks (Kochmar et al., 2021) and test the learners adaptively.

For instance, Schiaffino, Garcia and Amandi (2008) designed an adaptive intelligent tutoring system called as *eTeacher*. Their *eTeacher* builds each student's profile – comprising his/her learning styles and academic performance – and then proactively assists the learner by offering him/her personalized courses. Also, Eryilmaz and Adabashi (2020) designed another adaptive ITS using Bayesian network and fuzzy logic for a novel hybrid student model, and it proved to be more effective for e-learners' academic achievement compared to traditional e-learning.

As a productive skill, speaking in a foreign language is probably the most difficult skill to acquire for language learners because of several reasons, ranging from being shy to speak or having limited opportunities for practice in the target language to getting inadequate feedback. *Conversational agents* or *chatbots*, and *intelligent language tutoring systems* seem to be a good solution for developing speaking skills in foreign language. *Conversational agents* or *chatbots* can be defined as "an artificial (intelligent) construct that is designed to converse with human beings using natural language as input and output" by Brennan (2006). In our study, 9 papers were found to be relating intelligent language tutoring systems and/ or chatbots (Jia, 2009; Johnson, 2019; Procter, Lin & Heller, 2018; Tamayo, et al., 2020; Lippert, et al., 2019;Kang & Kang, 2021; Deveci Topal et al., 2021; Sun et al., 2021; Vázquez-Cano et al., 2021).

Another most commonly used function of ITS in distance education is to teach content and instruction (n= 11). In the review, some studies were on the use of intelligent agents for instruction of different courses such as Mathematics (Nabiyev, et al., 2013; Amanda et al., 2021; King et al., 2021; Mandal & Naskar, 2021), programming language Java (Troussas, Krouska, & Virvou, 2021), language proficiencies such as reading comprehension and vocabulary(Baker et al., 2021; R. Mariñas et al., 2021), music sight singing (Zhe, 2021), and Portuguese (Rodrigues, João & Vaidya, 2010). These researchers developed their educational agents for teaching courses and got promising results after having evaluated them (Vasijevic & Latinovic, 2020; Rouhani & Mirhosseini, 2015). Finally, the development of intelligent virtual assistants has become crucial during the pandemic especially in health sector due to a shortage of human sources and the necessity of maintaining social distance. Furlan and his colleagues (2021), for instance, designed an automated clinical training system, which assist medicine students improve their clinical diagnostic reasoning skills without having neither human tutors nor real patients. Also, other academicians proposed intelligent tutors for teaching surgical decision making (Vannaprathip et al., 2021), for training public health professionals online on epidemiology and surveillance skills (Matthews & Proctor, 2021).

Other roles of ITSs mentioned in the studies are to support and help distance learners by providing adaptive scaffolding in terms of feedback, guidance, recommendation, and other types of help (Binh et al., 2021; Lamia & Mohamed, 2019; Mohamed & Lamia, 2018; Hrich, Lazaar & Khaldi, 2019). Otherwise, some ITSs can facilitate collaboration by grouping the learners with similar interests, learning

experiences, and learning behaviours in MOOCs (Yang, et al., 2007; Casamayor, Amandi & Campo, 2009) or by detecting conflictive situations through the group works beforehand (McLaren, Scheuer & Mikšátko, 2010).

Next, one-to-one human tutoring, which is an effective method, cannot be possible in an e-learning environment all the time, especially with large groups. In this respect, machine intelligence as virtual teacher assistants (Paladines et al., 2021; Chou, Huang & Lin, 2011; Casamayor, Amandi & Campo, 2009) may be very handful to complement human intelligence (the teacher). Intelligent agents are also used for supporting the visually impaired students' learning (Pujari & Mukhopadhyay, 2012; Samigulina & Shayakhmetova, 2016; Lister et al., 2021; Matsuda, 2021) and for assisting children with specific learning disabilities such as dyslexia, dysgraphia, and dyscalculia (Thapliyal et al., 2022). Through the use of intelligent agents, it is possible to help the distance learners optimize their learning by customizing and adapting their learning time according to their concentration time (Kamsa, Elouahbi & Elhoukhi, 2018; El Mamoun, Erradi & El Mhouti, 2018). As an example, Matsuda (2021) designed a teachable agent that can play a dual role as a synthetic peer for students to learn by teaching and as an interactive tool for cognitive task analysis by teaching.

Consequently, in the review some articles focused on the use of ITSs for instruction and student modelling (Crowe, LaPierre & Kebritchi, 2017; Castro-Schez et al., 2021; Sychev et al., 2021; Mitchell, 2007; Solé-Beteta et al., 2021), and for enhancing critical thinking (Ivanovic, et al., 2015). Also, there are very recent studies focusing on the learners' emotional well-being through using ITSs by providing an affective sensitive learning environment (Alqahtani et al., 2021; Arguedas & Daradoumis, 2021; Taub et al., 2021; Vuković et al., 2021; T. H. Wang et al., 2021) Meanwhile, other studies were related with interoperable intelligent tutoring systems (Santos & Jorge, 2013), intelligent voice-enabled virtual assistants based on multiple agents working in conjunction with LMS (Laeeq & Memon, 2019), the evaluation of the effectiveness of ITSs and perceptions of distance learners' perceptions (Karaci, et al., 2018; Tacoma et al., 2021).

Adaptive Systems and Personalization

The current education systems are based on the philosophy of an industrial society, *i.e*., "one-size-fits-all" (Watson et al. 2015). However, in open and distance education systems, personalization ("fit-for-everyone") and adaptivity are key terms to design systems that are capable of addressing the needs of individual students. Customizing the syllabus, teaching content and materials, assignments and even tests according to each learner's learning style, prior learning, learning behaviour, and needs are indispensable in today's higher education. In the systematic review we conducted, the second most researched era of AI is adaptive systems and personalisation (n = 42).

The topic of the most researched was the recommendation of personalised content and materials for e-learning using artificial intelligence algorithms (n= 11). These studies aim to provide tailor-made content, online materials and resources (Bekmanova et al., 2021; Oliveira et al., 2021) in line with their learning styles, (Ozyurt, Ozyurt & Baki, 2013), learning path and knowledge level (Jia, 2018; Shpolianskaya & Seredkina, 2020; Saeidi Pour, et al., 2017; Gasparetti, et al., 2018; Thomas & Chandra, 2020; Khamparia & Pandey, 2018; Sungkur & Maharaj, 2021; Troussas, Krouska, & Sgouropoulou, 2021) in order to motivate the distance learners and increase their academic performance.

Since learning styles are considered to be one of the factors that influence learner achievement, intelligent systems can be used effectively to provide a personalised learning environment in open and distance education. 7 articles were found to be relating the use of AI technologies for recommending personalised learning environments consistent with students' learning styles (Al-Omari, M., Carter & Chiclana, 2016; Moise, 2007; Rajkumar & Gunapathy, 2020; Schiaffino, Garcia & Amandi, 2008; Ozyurt, Ozyurt & Baki, 2013; Hasibuan, Nugroho & Santosa, 2019), and with their prior learning (Deborah, et al., 2013). These recommendation systems developed (González-Castro et al., 2021; Kochmar et al.,

2021; Mousavi et al., 2021; Vedavathi & Anil Kumar, 2021; Villegas-Ch et al., 2020; Yang et al., 2021) can provide adaptive feedback and learning sources to online learners.

Furthermore, six other articles focused on the use of machine learning algorithms for offering each distance learner a personalised learning environment to stimulate his/her learning progress, and course engagement (Drąsutė, Drąsutis & Baziukė, 2011; Samarakou, et al., 2014; Saeidi Pour, et al., 2017; Qi, 2018; Khaled, Ouchani &Chohra, 2019; Moubayed, et al., 2020). In other papers, the predictive analytics were applied to provide customized learning tasks and questions in MOOCS, in which personalised learning is demanded more (R. Wang & Shi, 2021; Y. Zhang & Goh, 2021).

Moreover, adaptive intelligent systems can also provide e-learners with a guided learning mechanism in which learners are directed to successfully complete tasks, tests, and assignments. Some of the works (n= 5) in the study developed or/ and employed adaptive intelligent systems which follow competency-based guided learning algorithms (Hsu & Li, 2015), a guided learning mechanism that considers learners' skill level and their success rate (Mohamed & Lamia, 2015; Eryılmaz & Adabashi, 2020), works under a constructivist learning model (Xu, et al., 2014). Alternatively, Khaled, Ouchani, and Chohra (2019) presented a semantic analysis algorithm which guides the learners by providing them the best learning paths consistent with the recommendation of the best learning resources. Finally, two studies concentrated on the function of machine learning for personalised assessment and testing (Trifa, Hedhili & Chaari, 2019; Hedayati, Kamali & Shakerian, 2012; Yazidi, et al., 2020).

Learner Analytics: Profiling and Prediction

There is a growing demand in distance education for predictive analytics, which is the use of data, statistical algorithms of machine learning techniques to identify the likelihood of future outcomes based on historical data, in order to predict e-learners' academic achievement or failure at early stage. In our systematic review, 42 articles were on the applications of artificial intelligence for learner analytics. 15 of these researched the prediction of distance learners' academic achievement or failure, and their learning outcomes using predictive analytics, artificial neural networks, and educational data mining techniques (Herodotou, et al., 2019; Kotsiantis, Patriarcheas & Xenos, 2010; Costa, et al., 2017; Author, 2018; Aydogdu, 2020; Hussain, 2019 ; Aydoğdu, 2021; Jiang, 2021; Mubarak et al., 2021; Tang et al., 2021; Villegas-Ch et al., 2020; Xu, 2021; J. Yang et al., 2021; Yu & Wu, 2021; Wang & Shi, 2021). Furthermore, Knowledge Tracing (KT), which is another technique based on learner analytics of massive behavioural data, aims to predict online learners' performance on new problems regarding their learning histories (Gan et al., 2021). In addition, machine learning algorithms can be applied to predict the purchasing behaviour of MOOC learners about the course (Alshehri et al., 2021).

Another era predictive analytics approached is predicting drop-out rates at early stages in MOOCs and e-learning courses. Six articles focused on the use of machine learning methods such as Artificial Neural Networks (ANN), Decision Tree (DT), Bayesian Networks (BNs), and data mining techniques with the aim of identifying dropout- prone students and retention students in early stages of the e-learning (Mourdi, et al., 2020; Lykourentzou, et al., 2009; Yukselturk, Ozekes & Turel, 2014; Tan & Shao, 2015; Dass et al., 2021; Guerrero-Roldán et al., 2021). On the other hand, for analysing and categorizing posts and texts from MOOC forums to assess learners' academic success according to the quality and distribution of discourse, machine learning techniques are applied in some studies (Lee, 2021; Capuano et al., 2021).

Social presence-based interaction, which also stimulates online collaboration and the learning process, is essential for an improved collaborative e-learning environment. Grouping e-learners into groups with similar domain background, learning behaviours and styles by using machine learning techniques for improving collaboration in e-learning platforms proved to be effective (Anaya & Boticario, 2011; Dascalu, et.al. 2014; Blagojević & Micić; 2013; Šarić-Grgić, et al., 2020; Kardan, et al., 2013; Maté, et al., 2016; Alshmrany, 2021; Fang & Lu, 2021; Lwande et al., 2021). Another vital issue that triggers the

participation and performance of learners in online learning is their level of engagement and satisfaction with the course. Four recent articles applied predictive analytics to assess online learners' engagement by analysing their facial expressions and eye tracking while they are watching the videos, or solving the problems (Chango et al., 2021; Khedr et al., 2021; Li et al., 2021; Liao et al., 2021).

On the other hand, in some papers novel learning- design analytics were applied for recommending course design strategies to online educators (Yan et al., 2021), or recommending the best suited online courses to the learners (Rafiq et al., 2021).

Assessment and Evaluation

In the systematic review, it was found to be 28 articles were related to the features of AI technologies for assessment and evaluation. Recently, with an obligatory shift to distance education, e-learning systems have become very popular in higher education. Special software called Learning Management Systems (LMS) are the most commonly used technologies in distance education. Therefore, choosing the most effective technology for and then evaluating the effectiveness of the system in the institution may be a very challenging task for decision makers. In this term, four studies focused on the system evaluation of LMSs by using machine learning algorithms in order to help the decision makers select these e-learning technologies effectively and efficiently (Oztekin, et al., 2013; Salmeron, 2009; Fardinpour, Pedrum & Burkle, 2014; Cavus, 2010). On the other hand, in Karal and his co-workers' study (2014), the effectiveness of the expert system developed for Mathematics course was evaluated by the students. As Sir Richard Livingstone once said: "The test of successful education is not the amount of knowledge that pupils take away from school, but their appetite to know and their capacity to learn" (Livingstone 1941, p. 28). Therefore, assessing the distance learners' engagement level can be crucial to guarantee their academic success. Grubišić and his friends (2020), and Moubayed and his colleagues (2020) intended to assess the level of student engagement in e-learning platforms using machine algorithms.

Next, two studies (Samarakou, et al., 2014; Deborah, Baskaran & Kannan, 2013) focused on the importance of evaluating the distance learners' prior knowledge about the course contents to recommend the most suitable e-learning contents. Besides, the authors of one article in the review developed a brain-computer interface (BCI) so as to collect data and detect a MOOC learner's mental situation by observing electroencephalogram (EEG) signals (Balamurugan, et al., 2020). Additionally, Kaklauskas and others (2013) designed an intelligent pupil analysis (IPA) system with the intention of understanding how well distance learners have learned the content studied by analysing their pupil size. Otherwise, Ma and Li (2021) applied intelligent face recognition system to monitor the effectiveness of the online English teaching course.

User authentication, which is the process of verifying an authorizing an active user's identity, is one of the most important issues to be dealt with during online examinations. For this problem, two solutions that use biometric authentication by keystroke dynamics were proposed in the review (Khan & Alotaibi, 2020; Eude & Chang, 2018). In addition, Gudiño Paredes and his friends (2021) evaluated the impact of AI-supervised remote proctored exams during online learning. Another problem the authorities encounter with online assessment and evaluation is plagiarism so two articles were on the proposals of intelligent plagiarism detection mechanisms (Huang, Chu & Guan, 2007; Ullah, et al., 2020). Lastly, other works in the review focused on the use of machine learning for automated portfolio rating, and for grading the coherence in essays and tests (Huang, Chu & Guan, 2007; Fu, Zhong & Liu, 2014; Beseiso et al., 2021), for evaluating the general academic performance of online learners (Y. Yang, 2021), for assessing the levels of professional competencies (Barlybayev, et al., 2020), for detecting students' errors through mouse movement (de Mooij et al., 2021), for measuring e-learners' level of attention by monitoring their biometric behaviours (Durães, et al., 2019), and for tracking the integrity of distance learners in discussions on MOOCs (Mora, et al., 2017).

Affect Recognition and Affect Sensitive E-Learning

Compared to traditional face-to-face education, e-learning may lack interpersonal and emotional interaction between the teacher and learners because of the transactional distance. As a result, the learners may feel alone, demotivated, and disengaged during the challenging process of e-learning. In the review, 14 articles address the issue related the use of machine learning methods for affect recognition and establishing an affect sensitive e-learning environment. Three papers researched on evaluating emotional states through the e-learning course via hybrid intelligent approaches such as head pose, eye gaze tracking, facial expression recognition, physiological signal processing and learning progress tracking using webcams, microphones, 3D tutoring system (avatar) with haptics to overcome the barrier between the man and the non-emotional machine (Basori, Tenriawaru & Mansur, 2011; Magdin, Turčáni & Hudec, 2016; Chen, et al., 2016). The other 3 articles employed machine learning methods to detect the engagement of the e-learning and the level of learning attention by recognizing their affective states (Behera, et al., 2020; Hwang & Yang, 2009; Ashwin & Guddeti, 2020). Also, the others focused on recognition and classification of academic emotion via eye gaze tracking (Ever & Dimililer, 2018; Feng, et al., 2020; Troussas, Espinosa & Virvou; 2016). Consequently, most recent papers designed affective virtual tutoring systems, which can detect the emotional state of learners during online courses with the use of physiological signals and machine learning and can give them affective feedback for their emotional well-being (Alqahtani et al., 2021; Arguedas & Daradoumis, 2021; Myers, 2021; Taub et al., 2021; T. H. Wang et al., 2021).

Virtual Learning Environments

Virtual Learning Environments (VLEs) have been used for training the learners in simulated settings using intelligent Augmented Reality to immerse learners into settings they will able use real, hand-on skills needed for their future work. In the study, only six articles were related to the application of intelligent systems in virtual learning environments for distance education (Buche, et al., 2010; Grieu, et al., 2010). Buche and his colleagues (2010) proposed an independent VE tutoring system called PEGASE for procedural and collaborative works. Next, Grieu and his friends (2010) developed a virtual campus called GE3D, which is based on multi-agent systems and embedded in the intelligent tutoring system using 3D technology. During pandemics, virtual environments and virtual patient simulators are used especially for training professionals at health sector to teach surgical decision making (Rafiq et al., 2021), or to improve students' clinical diagnostic reasoning skills (Furlan et al., 2021). Moreover, two articles applied virtual delivery using 2D and 3D formats for practical based programmes and then evaluated their effectiveness (Paladines et al., 2021; Saleeb, 2021).

Conclusions and Suggestions

In this systematic review, we have investigated the genre of AI in open and distance education (AIODEd) research with respect to authorship and publication patterns. As a result, most of the articles (n= 116) have been written recently, after 2018. Also, it is obvious that Chinese, Spanish, Turkish, American, and Indian academicians (with cumulative percentage, 43%) from Computer Engineering, Information Sciences, and STEM departments (79%) dominate the field. The leading journals are the *International Journal of Emerging Technologies in Learning (IJET), Computers & Education, International Journal of Artificial Intelligence in Education,* and *Complexity.* Lastly, six research areas of AIODEd were coded as, *ITSs, Adaptive systems and personalisation, assessment and evaluation, Learner analytics, affect recognition*, and *virtual learning environments,* with 28 subcategories.

In summary, the study demonstrates that artificial intelligence (AI) can be utilized in distance and open education for both *pedagogical* solutions and *system-wide* solutions. Pedagogical solutions AI presents may be the pedagogical agents and intelligent tutoring systems to support teaching and learning process, the expert systems to provide adaptive and personalised e-learning environment, and the

chatbots and conversational agents to enhance collaboration and engagement. The system-wide solutions AI provides may be data analytics in education management information systems, which may also work as decision support and recommender systems, to help educational authorities make decisions about the system and evaluate the effectiveness of the teaching and learning process. Furthermore, these findings are parallel with du Boulay's categorization of intelligent educational tools (2022), which have been designed to be used for assisting learners, teachers, and/ or administrators.

Furthermore, the review indicates that most recent studies (after 2018) have focused on the research to establish affect-sensitive e-learning systems for effective interaction and student engagement and to ensure exam security via detection of plagiarism and user authentication by employing machine learning algorithms. In this perspective we can conclude that the recent research trends are concentrating on breaking the emotional barriers between the human learners and non-human machine tutors via smart affective computing, which is parallel with Aljarrah and his co-workers' findings (2021). It is evident that with massive spread of e-learning after Covid- 19, educational authorities need more intelligent exam security techniques such as user authentication and proctored exams for their distance evaluation systems. Also, the demand of virtual learning environments for training professionals – especially in health sector – has increased in pandemics years, 2020-2021. In other words, these findings indicate that the prospect of open and distance learning is likely to be AI-powered since AI technologies can bring effective solutions to disruptive situations in e-learning even in times of crisis.

Besides all these opportunities of AI applications in distance education, there may be some challenges for its sustainability and adoption. Zhai and his colleagues (2021) classified the challenges of AI may confront in education into 3 categories: technique perspective, the reconceptualization of teacher's and students' role, and ethical concerns. Additionally, Pedro and others in the UNESCO report presented six challenges and policy implications for the introduction of AI in education (AIEd) in the local context. They are as follows: building a complete understanding of public policy on AI for sustainable development; ensuring inclusion and equity; preparing instructors for an AI- powered education while preparing AI to comprehend education; developing data systems that are both high-quality and inclusive; making AI research in education essential; and confirming ethics and transparency in data collection, use, and dissemination (2019). Moreover, all the research mostly gave emphasis on the design and development of AI tools without any learning and educational theory, which is a great deficiency for the sustainability of these very expensive and laborious intelligent technologies.

Since most of the studies mentioned above were empirical studies, they presented mostly positive results of AI applications in distance learning. However, there is a need to research the challenges or misunderstanding of AI tools in terms of technique, domain knowledge, pedagogical design, human factors, and ethics. Firstly, there is a compelling need for exploring the ethical issues and human factors in the use of AI in education. As Sharma, Kawachi and Bozkurt (2019) emphasized there should be some control mechanisms and ethical codes for the transparency of AI data while collecting, applying, and spreading out, and for the protection of human beings' entity and their privacy. Next, open and distance learning organizations' readiness level for applying AI technologies requires be researched because the adoption of this very expensive and laborious technology can be challenging for the institutions at organizational level. As a result, exploring these institutions' readiness level for AI adoption beforehand may minimize the future problems. Furthermore, academicians can study on the design of an AI powered curriculum in order to prepare both teachers and students for AI saturated future. In conclusion, future studies on AIEd may extend the research scope to include the topics related to the assessment of the readiness level of the academic institutions, with opportunity to leverage and use of AI; the design of a new curriculum for AI powered world; and the preparation of students and teacher for AI saturated future.

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Acknowledgements

Not applicable.

Funding

Not applicable.

Ethics Statement

Because this study doesn't involve any living entities, an ethics review is not applicable.

Conflict of Interest

The authors do not declare any conflict of interest.

Data Availability Statement

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Suggested citation:
Gocmez, L. & Okur, M.R. (2023). Artificial intelligence applications in open and distance education: a systematic review of the articles (2007-2021). *Asian Journal of Distance Education, 18*(1), 1-32. https://doi.org/10.5281/zenodo.7514874