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Tumaini Mwendile Kabudi

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Artificial Intelligence for Quality Education: Successes and Challenges for AI in Meeting SDG4

Tumaini Mwendile Kabudi
University of Agder, Kristiansand, Norway
tumaini.kabudi@uia.no
[ORCID 1](#)

Abstract: The application of artificial intelligence (AI) in education has brought significant transformations to traditional models of education. Despite its potential to provide quality education, AI applications in education raise significant concerns. The goal of this paper is to understand how to increase AI implementation in education by identifying practical benefits and challenges that must be addressed if AI is to be harnessed to achieve Sustainability Development Goal 4. Twenty-two interviews were conducted with AI experts. Several rounds of analysis of the interviews revealed five main themes: 1) the role of the teacher in AI in education (AIEd); 2) the inclusion of students with intellectual disabilities; 3) racial and data bias in AIEd; 4) design issues of AI-enabled learning systems; 5) and commercialization of AI-enabled learning systems. The findings of this study contribute to the ongoing research on AI in education and help build a better understanding of AI's role in achieving SDGs.

Keywords: *Artificial Intelligence, AIEd, Sustainability Development, SDGs, SDG4, Education*

1. Introduction

The recent wave of technological innovation is based on artificial intelligence (AI). AI is considered to be a system that uses machine learning, data mining, computer vision, language recognition and natural language generation to collect data and to predict, recommend or decide the best line of action [1]. More recently, the United Nations acknowledged that this pervasive emerging technology can rapidly accelerate progress in pursuing its global agenda of sustainable development [2]. UN's global agenda goals regarding sustainable development, known as Sustainable Development Goals (SDGs), cover a range of social, economic and environmental matters. Given the role of education as an enabler of economic development, one of the SDGs deals specifically with education, namely SDG4, that is, "Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all" [2], [3]. AI is already changing the education sector. Students now have the capability to find information at their fingertips through educational software and reactive products such as Leapfrog, Amazon's Siri and Google's Alexis [4], [5]. AI offers unprecedented opportunities to humanity and thus solves educational challenges, such as expanding the availability of education, making learning more interactive and personalising learning [6]. AI applications are increasing in the field of education, from laboratory setups to contemporary and complex learning systems. A great example of such systems is AI-enabled adaptive learning systems (AI-ALS) and Intelligent Tutoring Systems (ITS), which promote adaptive learning. The application of AI in education (AIEd) has increased due to its promising potential to provide personalised and adaptive learning, provide instant and correct feedback, facilitate meaningful interactions and improve students' engagement. Moreover, AI has the potential to have a major effect on administrative tasks, data mining and data analytics due to its powerful processing capabilities. AI is also used in learning assessments, such as grading essays [7]. AI offers other great opportunities, such as the integration of serious games into ITS and intelligent agents in the form of chatbots. Thus, AI has been transforming the ways of teaching and learning in education and has contributed to maintaining high-quality teaching during global crises, such as the pandemic [8].

The potential and importance of such systems is well established; however, AI-enabled learning interventions and applications, especially AI-ALS, remain largely at the experimental stage [9], [10]. A recent literature review noted a critical gap between what AI-ALS could be and can do and what the current systems do in terms of how they are implemented in real educational environments [11]. There is a severe discrepancy, which has been consistently noted between the potentials of AI-ALS and their actual implementation in real teaching and learning settings [12]–[14]. The increased need for AI-ALS to be further utilised and adopted more quickly in education demands more empirical research on the implementation and evaluation of these systems. Moreover, AI has yet to be adopted in most of the poorest regions of the world. AI can provide financial and intellectual superiority to some countries, while other

countries will be left behind [4]. Thus, the provision of more inclusive access to education to all students using AI in less affluent countries is a persistent challenge, as AI is still an unknown concept in such a context [15]. Moreover, research reports such as UNESCO (2021) have connected AI and SDG4, but little research has been done on the evidence-based implications of AI in schools and universities. With AI evolving rapidly in the education field, issues such as the integration of AI-ALS systems within real education contexts need to be addressed. Hence, more research is needed to understand how to increase the implementation and adoption of AI in education (AIEd).

Thus, this article identifies the existing practical benefits of AI in education and the challenges that need to be addressed in harnessing AI to achieve this SDG. Therefore, the motivation for this research is to investigate the following research question:

RQ: How can researchers, developers and designers successfully integrate and implement AI technologies in education to accomplish SDGs in quality education?

To address our RQ, in-depth interviews with AIEd technological experts who are knowledgeable about the design and development of AI-ALS. The findings of the study contribute to the ongoing research on AI and show how IS research can lead the way in harnessing AI to achieve SDG4. Moreover, it contributes to ongoing research on the digitalisation of education and shows how IS research can lead the way in designing the learning systems of the future. Better education, especially in a developing context, would lead to significant benefits for such societies and positively affect other SDGs, such as SDG5, SDG10, SDG9 and SDG16. Henceforth, this article will help the AI in Education (AIEd) community build a better understanding of AI and SDGs. In the following sections, the theoretical background is provided. The author provides a literature review of the opportunities and challenges of AI in education. Then, the author describes the research design of the study in detail. The data collection and analysis steps are described and elaborated upon in detail. Finally, the findings are inductively derived and discussed in the context of what happens in practice and in the existing literature. This paper then concludes with the implications of the study and recommendations for future research.

2. State of the Art: Vis-à-vis Opportunities and Challenges of AI in Education

Artificial intelligence (AI) has advanced and has been widely adopted in various fields, including education. With AI technology thriving in recent years, its applications in the form of AI-ALS have increased [16], [17]. AI-ALS are generally digital learning tools enabled by AI that “adapts, as well as possible, to the learner, so that the learning process is optimized, and/or the student performance improve” [18]. AI-enabled adaptive learning systems (AI-ALS) are platforms that adapt to the learning strategies of students, changing and modifying the order and the difficulty level of learning tasks based on the abilities of students [17], [19]. These systems support adaptive learning (i.e., personalisation of learning for students in a learning system) in a way that allows the system to deal with individual differences in aptitude [16]. Most recent AI-ALS include Smart Sparrow, Knewton, Fishtree, INSPIREus, ProSys, QuizBot, OPERA, LearnSmart, Connect™, ACTIVEMATH and Student Diagnosis, Assistance, Evaluation System based on Artificial Intelligence (StuDiAsE) [11]. AI-ALS was developed to help address most challenges that occur in technology-enhanced learning environments. These include resource limitations, difficulty in students attaining and mastering their learning skills, variety in learning abilities of students and diverse student backgrounds [11], [20]. AI-ALS motivates students to embark on their own learning journeys through automated feedback cycles in these systems. The ability of AI-ALS to enable the personalised learning of students sparks in them interest in the field of education and thus increases students’ enthusiasm [16]. This is mainly due to the promising potential of the systems, such as providing customised learning to students (adaptive learning), offering fast feedback and dynamic assessments and facilitating meaningful group collaboration and engagement in learning settings [21]. In addition to AI-ALS, other AIEd technologies include ITS, expert systems and chatbots [22].

Such advances in contemporary educational technologies and digital education have sparked increased interest in enhancing teaching and learning [23], [24]. Figure 1 illustrates the potential or proven benefits of AI in education. AI-ALS and other AIEd technologies facilitate learner engagement, varied interactions with learners, and improvement of learning outcomes, in addition to helping lecturers and administrators identify gifted and at-risk students, monitor learning progress and provide feedback [22]. AI offers other great opportunities to meet SDGs for quality education globally. For example, issues such as teacher modelling and multimodal interaction, emphatic systems and the use of educational robots offer unprecedented opportunities for research into issues such as diversity, inclusive education, equitable quality education and ethical concerns [25]. Moreover, AI in education contributes to addressing long-term educational targets (i.e., as part of SDG4). These include attaining and learning 2st Century skills; universal access to

global classrooms; lifelong and life-wide learning; interaction data to support learning; and mentors for every student [26].

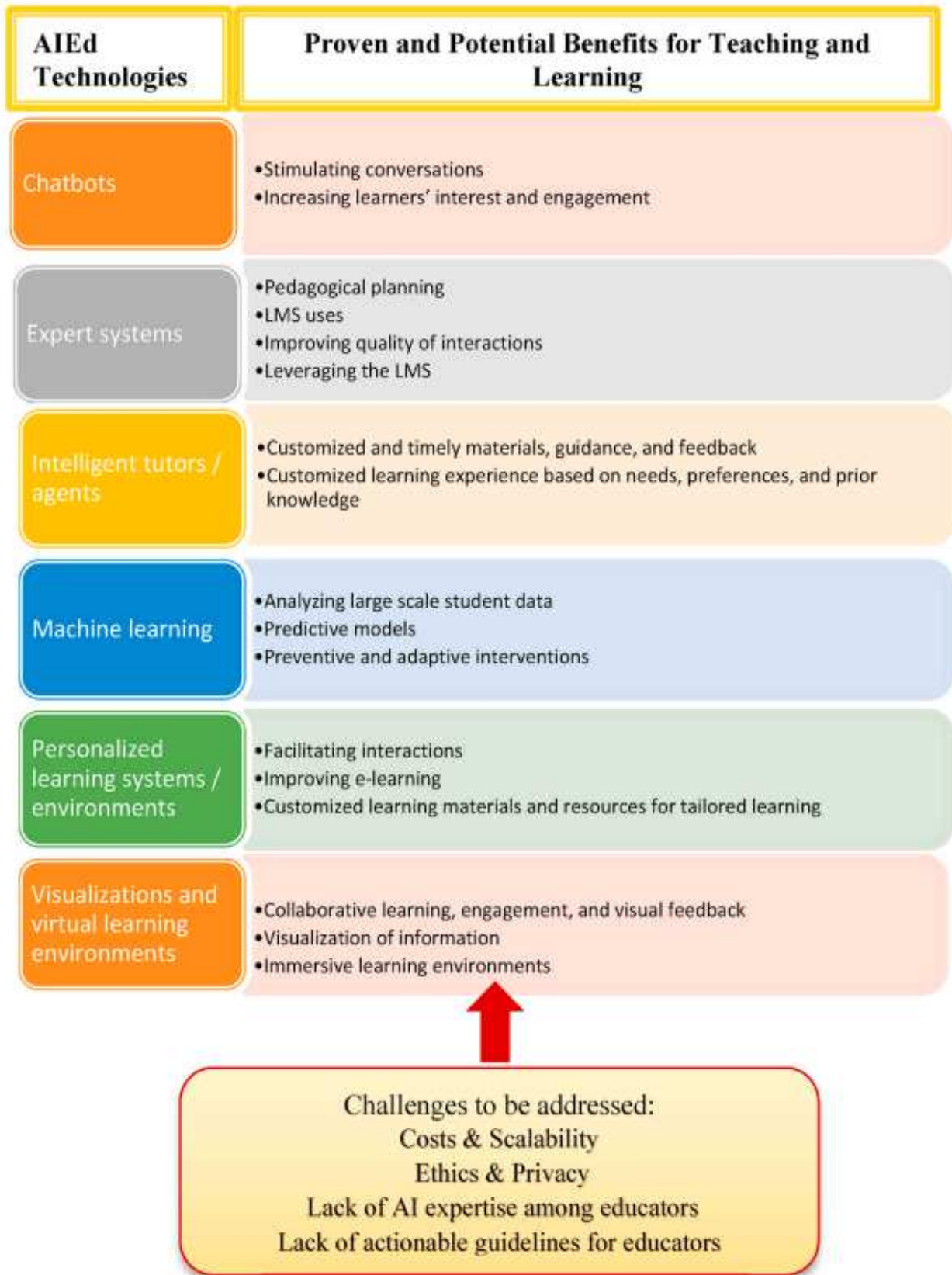


Figure 1 Benefits and Challenges of AI in Education [22]

Although AI holds great promise for providing quality education for all, its application in education comes with challenges. [2], [3] have pointed out several challenges and risks of implementing AI in education that can thus affect SDG4's realisation. These challenges include ensuring the equity and inclusion of AI in education. The least developed nations, as it stands, risk suffering other technological, social and economic disadvantages due to AI [3]. In addition, developing quality and inclusive data systems is another concern. Other concerns in implementing AIED include ethics and transparency in the collection and use of learners' data; preparing teachers for AIED while preparing AI to understand education; and developing a comprehensive public policy on AIED for sustainable development. AI has raised significant worries and ethical concerns, such as replacement of teachers, job loss and algorithmic bias [27]. Furthermore, AI has the potential to aggravate inequality and further entrench the control and supremacy of big tech companies [28]. Access to affordable electricity, internet and smart devices, which are prerequisites for AIED, are not equally distributed in developing contexts and may instead present new forms of inequalities. There has been little demonstrable positive impact of AI on education in terms of enhancing equity and quality [29]. In addition, although the provision of quality education is at its core, the role of digital infrastructure and technology in the realisation of SDG 4 is not addressed commendably in the SDG4 targets. Therefore, the impact of AI on students, teachers and society in general has yet to be determined [2]. Issues such as the effectiveness of AIED interventions, the choice of pedagogies used in these interventions, gender-equitable and AI for gender equality and data ethics have yet to be addressed. Thus, this research aims to address the above-mentioned gaps by identifying the practical benefits and challenges that must be addressed to increase AIED implementation.

3. Research Design and Methodology

I followed Yin's [30] argument that qualitative research methods address "how" questions. Therefore, the research design for this study is based on a qualitative research methodology. Grounded theory was used to guide the study, as it served to explain in conceptual terms what actually occurs in practice. The theory also helped in interpreting the collected data and extracting the literature during the study [31]. The author conducted an empirical examination of the DPs using expert interviews and content analysis. AI technology experts involved in the design, development and extensive research on AI in education were interviewed. Content analysis was used to code phrases, sentences and paragraphs. The results obtained were used to discuss the benefits of implementing AI in education and the challenges that need to be addressed. In the following sections, the data collection techniques and analysis are described and discussed.

3.1. Data Collection via Expert Interviews

Throughout a 3-month period, a series of semi-structured interviews with experts were conducted. This method was used to explore and understand the perspectives of AI technology subjects involved in developing, designing and implementing AI-ALS. Moreover, this method was considered suitable because the author could collect in-depth information from several experts across the world during the pandemic. The experts were selected using the snowball sampling technique based on their publications and work. This technique was quite practical, since it allowed us to collect data during a pandemic. Relying on a literature search and Google Scholar profiles, the author identified 143 experts who had published research on AI-ALS and appeared to be active in the AIED community. They were randomly selected using a convenience sampling technique. The experts were then contacted via email. Data were collected until theoretical saturation was achieved on various aspects of participant experiences and perspectives regarding the development, design and implementation of AI-ALS—the focus of this study. The demographic profiles of the experts are presented in Table 1. The interviews were conducted face-to-face using a video conferencing tool. All interviews were anonymous and confidential. The expert interviews lasted between 45 min and 1 h. The questions in our interviews were used to help answer the main research question. The semi-structured interview questions focused on the implementation status of AI-ALS, its major benefits and the perceived challenges in its implementation. The interviewer asked probing questions for further elaboration based on the information provided by our experts. The interviews were conducted in English, although some of the interviewees and the interviewer's first language was not English. Thus, some of the nuances of the language may have been lost during the transcription of the interviews.

Table 1 Profile of the Respondents

#	Organisation	Expert Category	Role	Country
1	University	Researcher, Designer, Developer	Academic	Australia
2	University	Designer, Developer	PhD Student	Switzerland
3	Consulting Company	Researcher	Project Manager	France
4	Research Lab	Researcher	Academic	Tunisia
5	University	Researcher	Academic	Switzerland
6	Industry	Designer, Developer	Software Engineer	UK
7	University	Researcher	Academic	Germany
8	Research Centre	Researcher	Co-Director	UK
9	University	Researcher	Academic	USA
10	University	Designer, Developer	PhD Student	USA
11	Research Lab	Developer, Researcher	Head of Research Lab	Russia
12	University	Researcher	Academic	China
13	University	Researcher	Academic	UK
14	University	Designer, Developer	Academic	USA
15	University	Researcher	Academic	Brazil
16	University	Designer, Developer	Academic	Singapore
17	Research Lab	Designer, Developer	Academic	Morocco
18	University	Developer, Researcher	PhD Student	South Korea
19	University	Researcher	Academic	Ukraine
20	Research Centre	Researcher	PhD Student	USA
21	Research Lab	Researcher	Academic	UK
22	Research Centre	Researcher	Academic	USA

The semi-structured interviews were conducted from July to November of 2021. These interviews took place mainly at the most convenient time for the interview subjects. The interviews were conducted face-to-face using a videoconferencing tool. The interviews were transcribed verbatim, focusing mainly on spoken words. The text transcripts were stored on a secure file served and identifying labels were removed from the file names.

3.2. Data Analysis

After the interviews were conducted, they were transcribed. The interviews were recorded, both in video and audio formats, and represented in total approximately 22 h of conversation. This was a large amount of qualitative data, and each recording took 6–8 h of transcription work. The author independently transcribed the English-language transcriptions using qualitative data analysis software (NVivo). The transcriptions were then reviewed and inspected for accuracy and corrected if needed. The coding and evaluation of the expert interviews were then conducted through qualitative thematic analysis. This method is the most comprehensive and precise approach to analysing data collected qualitatively [32]. An open coding process, according to [33], that generates first order codes/themes was used. An initial list of generated codes was first developed based on the identified sentences and paragraphs. Pattern coding was employed for the categorisation of the coded data. Pattern coding was used to move from an unrelated list of codes to

central themes that could be explored. This was done through a process of constant comparison between the initial codes, where common patterns were detected and thus organised into first-order themes. In any IS research, it is important to build on the obtained prescriptive knowledge to provide solid grounding [34], [35]. Through an iterative approach of developing, revising, comparing and recategorizing codes, five major themes and their multiple sub-themes emerged.

4. Discussion of Findings

This section presents the findings of the data collection. The findings reported in this paper are based on the analysed data collected from 22 interviewees. Of the 22 experts who were interviewed, 6 were female and 16 were male. The majority came from the USA (5), followed by the UK (4) and Switzerland (2). Moreover, the majority of these experts came from universities and research groups.

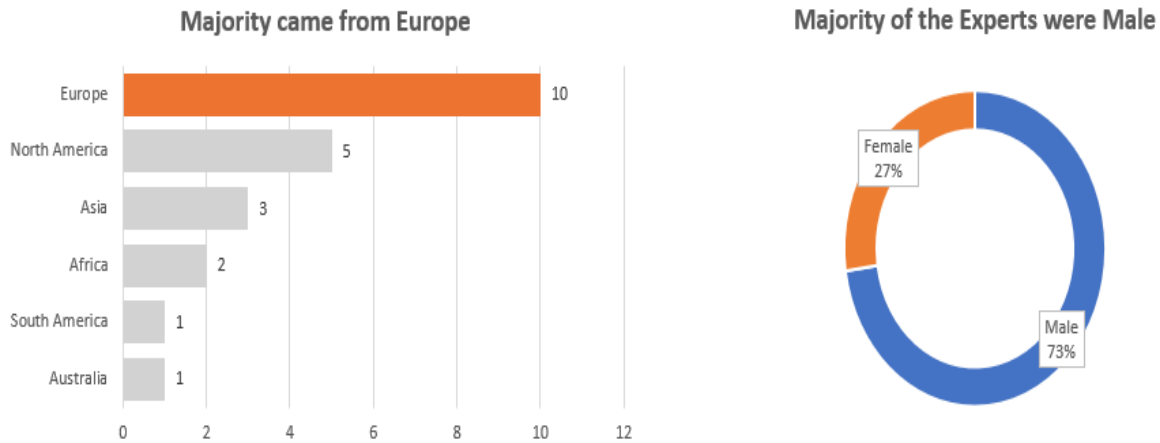


Figure 2 Demographics

Five major themes emerged after the analysis. The themes were based on experts' perspectives on the implementation status of AI-ALS, significant practical benefits of AI-ALS and the challenges perceived during the implementation of AI-ALS. The themes included 1) the role of teachers, 2) racial and data bias, 3) inclusion of students with intellectual disabilities, 4) commercialisation of AI-ALS, and 5) cultural design issues. Each of these themes is further detailed in the remainder of this section.

4.1. The Role of the Teacher in AIEd

The value and role of the teacher in AIEd was a prominent theme discussed by the experts in this study. The majority explained that the intention of building AI-ALS was not to replace teachers in educational settings. The following are excerpts of experts' statements on the value of the teacher:

“There are some people in AI and education who kind of see themselves as replacing teachers, which I think is nonsense. Even if it sorts of worked, it would be nonsense, you know, because actually, education is preeminently a social interaction between teachers and learners in in a social context”. (Expert 12)

“And I just think that's important to reinforce is there's nothing in learning analytics as a paradigm that seeks to replace a teacher”. (Expert 21)

“One of the things that I strongly believe is that we're not trying to develop a system that replaces teacher . It would be something teachers use to help them and that would be with the teachers being present a lot of the time as well. So it's not like how our students have had to suffer during COVID restrictions, where they've just been stuck in front of a screen on their own... (so) we didn't envisage a system that will replace a teacher... ”. (Expert 13)

“I don't know about your country or other countries, but there are still teachers here who feel they are being replaced and they don't like it at all. With the ones who build it, we never thought of replacing teachers. I mean, teachers have an incredible and difficult job to do, and I've never thought of replacing

them". (Expert 20)

"...If we're going to talk about any kind of artificial intelligence that exists within the field... it should be artificial intelligence that is applied to that specific problem.... (And thus) of how do we use artificial intelligence not to replace teachers, but to assist teachers in doing their job better". (Expert 20)

Hence, teachers play an important role in AIEd. Some teachers understand the benefits of using AI in their classrooms. Expert 13 gave good examples of teachers' positive perspectives on AI-ALS. She stated: *"As the positives for the teachers were that they thought it would actually free them up to do other things. They thought it would be, you know, when you're trying to share your time between lots of different students, you could maybe take your eye off the ball with ones that were doing well and spend more time with those that were struggling. And the fact that they will be developing their own versions, as the idea is to give them a platform that they could then tailor themselves".* Expert 20 also highlighted how teachers enjoyed uploading their own content on these systems, specifically the ASSISTMENTS system. ASSISTMENTS has been successfully and widely adopted in the USA because *"it gave teachers templates for creating new content that teachers can use to make their own problems... that their students can work on, and that they can share with other teachers. They don't have to do the rigorous skill mapping or the misconception mapping because that takes a load of time and teachers don't have time to do that".* Thus, these advantages, in addition to providing teachers with information about their students using learning analytics, encourages them to use AI-ALS. This helps harness AI to achieve SDG4.

Nevertheless, teachers also displayed negative attitudes towards AI. The overwhelming negative attitudes of teachers towards AI-ALS were defined by the heavy workload related to designing each course or discipline with a modular approach, and thus populate the different aspects of the platform (Experts 2, 11 and 13). Most teachers tended to be busy and had specific plans and thus felt that AI could be disruptive (Expert 10). Teachers also felt that they needed to have some sort of incentive to do such work (Expert 1) or have technical support to help develop their content in these systems (Experts 1 and 5). Moreover, teachers felt that the systems enabled by AI were too advanced, complicated or hard to understand. Unlike learning management systems such as Canvas, AI-ALS resemble a "black box" that was inflexible for teachers to use (Expert 9). Teachers not being technologically and pedagogically skilled to use AI-ALS discouraged them from embedding such systems in their classrooms (Experts 2, 14 and 21). Thus, it was challenging to find lecturers who were willing to use AI-ALS in their curricula.

4.2. Racial and Data Bias in AIEd

Other significant themes that emerged in this study were data bias and racial and inequality issues. Several researchers, such as [36] and [37] have explicitly identified case issues related to data, racial and other ethical concerns in AIEd. Expert 20 provided reasons for the existence of such racial and data bias: *"I'm sure that you know a common critique of the field is that it's predominantly white and male, and a lot of the algorithms that we produce are really good at predicting people who are white and male but tend to struggle in a lot of different areas".* Moreover, due to racism and inequality existing in most countries, there has been unequal access to quality education. Expert 14 highlighted this: *"Because of the racial split in the United States, it's the poor and the urban, the people whose parents had to go out and work... parents who had a frontline job or we're in the service sector...that didn't get any support to study and work online...Is the same in the United States as anywhere else, you know, poor people...urban people get an inferior education. In the United States, especially because of COVID, the country is starting to admit that's a huge racial bias and huge lack of resources for students of color".* Gupta *et al.* (2020) indicated that access to affordable broadband internet and smart devices, which are prerequisites for digital education, are not equally distributed and thus may introduce new forms of inequalities. Therefore, racial bias and inequality affect SDG targets related to providing free, affordable and quality education to all women and men (Targets 4.1 and 4.3). Other barriers that affect AI implementation in terms of meeting SDG4 were incorrect use of data and issues relating to modelling false negatives and false positives (Experts 12 and 21). Expert 12 elaborates on this: *"Let's take the example of looking for evidence that a student is not doing too well and need extra help. They look over past data about students and they try to find patterns in the data which say these students look like they need help. So, they compare the new student against data for those previous. Now that can kind of go wrong because you can get false positives and false negatives; you can end up offering a student who's doing perfectly well extra help which he or she doesn't need. That's not too dangerous, but it's a waste of resource".* Thus, the wrong application of AI models and racial and data bias are crucial issues to be addressed.

4.3. Supporting Students with Intellectual Disabilities and Autism

One of the other interesting insights identified in this study was the application of AI in assisting students with autism and intellectual disabilities. Much research has been conducted that reveals the positive outcomes of using AI in the field of intellectual disabilities (Kazimzade, Patzer, & Pinkwart, 2019). Expert 13, for instance, conducted research to determine whether adopting technology in AI-ALS can help people who have cognitive challenges with school-based learning. Expert 6 also employed AI-ALS in two vocational schools for students who needed special educational assistance. Inclusive education is a target promoted in SDG4, with the explicit objective of ensuring equal access to all levels of education for persons with disabilities (Target 4.5). Thus, AI demonstrated effectiveness in meeting SDG4. However, several barriers were identified in using AI to assist such students. One major barrier was capturing students' data issues. Expert 13 gave the following example: *"There was one (student) that I was working with who wouldn't look at the camera, so we couldn't pick up lots of things. She sat sideways the whole time"*. Expert 6 identified this as well: *"Students with special education needs might not want to sit behind a computer patiently for a very long period of time; they might find it boring"*. Such cases impede the collection of student data, which could build a better future for AI-ALS systems. Other barriers highlighted were time and money issues. Again, Expert 6 elaborated on this: *"There is a lot of popular tools that teachers might already have in a special educational needs environment. They might not be translatable very easily to this (AI-ALS) system (in terms of content etc.), which might cause the adoption to be very expensive and time taken so it's all of that"*. Such barriers impede the role of AI in implementing SDG4.

4.4. Culturally Sensitive Design Issues of AI-ALS

Culturally sensitive design issues have also been identified as another theme. Mohammed and Watson [25] has explicitly identified and examined issues related to challenges faced when AIEd technologies aim to incorporate culturally sensitive design features. Contemporary learning systems, such as AI-ALS, are sometimes not adopted simply because of cultural design aspects. For instance, there are cases of contemporary learning systems that were built for one ethnicity being used for another. A good example of this was given by Expert 12: *"Let's say university has got a lot of Chinese students but the (learning system) model was built on European students. Now it could be that a Chinese student who maintains you know much calm face no matter what, is not helped. Because the model has been built on European students. So, I mean, we've gone offside bit sideways slightly, that is an educational consequence of building models you know"*. Thus, a lack of insufficient data for other ethnic groups impedes ensuring the provision of quality education for all (SDG4, Targets 4.1 and 4.3). Another example of cultural design mistakes was highlighted by Expert 5, in which they conduct projects for German companies that produce and develop systems in China: *"Their way about thinking and training is of course a German way of thinking about teaching and learning. So, what they do is they translate everything to Chinese and deploy it there. And (then they) are surprised that it doesn't work because apparently the culture refrain for a Chinese person. We know from interface design that Asian cultures have a different preference for interfaces. It's much more blinking and shining...So you need to translate that also to learning systems, right...And out of the blue you end up with what we would call cultural design of such systems"*.

4.5. Commercialisation of AI-ALS

There have been efforts to adopt AI-ALS widely and to commercialise it, which were initially developed in research. Expert 1 gave an example of Pearson acquiring the Smart Sparrow system. This system was initially developed by the University of New South Wales by the Adaptive eLearning Research Group at the School of Computer Science and Engineering. Expert 13 also discussed the commercialisation of AI-ALS: *"It was interesting...actually one of the aims of EU funding is try get you to the stage where companies are just ready to bite your hand off and take this product for commercial development. And we did have lots and lots of contacts, so when we had the final review meeting, the people who were responsible for commercialisation of it gave lots of companies..."*. The commercial development of AI-ALS has assisted in the wide adoption of these novel learning systems and can thus help achieve SDG4 by ensuring equal access to quality education (Target 4.3).

However, despite the significant efforts, there are still issues that challenge the ability of AI to meet SDG4. One identified issue is the fact that some AI-ALS have become proprietary systems and thus no longer affordable and free. Expert 1 expressed his disappointment in detail: *"And I believe...a major reason why these systems are not widely adopted. First, because they are expensive because they are proprietary, so they are closed systems and people want things that are more open, that they can develop something, that they can reuse, you know, and export. And that's a major problem, because if I look back and I see the work that was involved and then I cannot really take advantage of*

it, it it's really disappointing". Expert 13 also noted that she did not see anything being done by companies responsible for the commercial development of AI systems after their review meeting during the EU funding process.

5. Implications and Recommendations

A nation's development is generally determined by the quality of education its society provides. This is substantiated by the United Nations' decision to formulate SDGs, including SDG4, which focuses on education [38]. To achieve SDG4, three key areas need to be addressed: education facilities and learning environments that are safe and equipped with advanced technology, support for students to obtain regular access to education (financial and otherwise) and an adequate supply of qualified and motivated teachers [39]. At present, AI is becoming increasingly important and integral to supporting global sustainability trends and quality education. Researchers and innovators using AI-ALS are advancing education and assisting in achieving SDG4.[2]–[4], [40] and [15] show the importance of AI in SDG4. We extend these findings by conducting a qualitative case study on the role of AI and identifying benefits and challenges for AIEd implementation. This study contributes to ongoing research on how AI can provide quality education for all. The study also contributes to the literature by identifying challenges impeding AIEd implementation, such as algorithmic bias and poor representativeness. The study provides important insights for practitioners and educators who are interested in using AI to achieve SDG4. In this section, the implications of the study and recommendations for future research are discussed.

One of the practical implications of this study involves the role of AI and teachers in education. More research should be done to reinforce the role of AI in assisting teachers, not replacing them. Several studies, such as [41], [42] and [43], have discussed this issue. Moreover, there should be more research on the benefits of AIEd implementation. These benefits include helping reduce the teachers' workload, communicating with students, helping students, and improving the effectiveness of systems in tutoring students (Experts 10 and 21). Another recommendation is to train teachers on how to use AI-ALS so that they can improve their teaching and productivity (Expert 5). Teachers should be encouraged to learn new digital skills to use AI in a pedagogical manner, while AI-ALS developers should also learn how teachers work to create sustainable solutions in real educational settings [3]. Further research on the pedagogical aspects of AI-ALS should also be conducted. Expert 18 stated that the above is possible through more collaboration (interdisciplinary work) between educational (pedagogy) and technical experts. Thus, the call for invitations for AI experts and educational researchers to fully collaborate in the technological innovation process will further advance AIEd [22].

Moreover, developers and researchers in AIEd should have a contextual understanding of the learning systems enabled by AI. It is noteworthy to consider and understand education in its social context. Education is preeminently a social interaction between teachers and learners in social contexts (Expert 21). The main objects of any educational setting are human learners and teachers. Thus, there needs to be more attempts to develop systems that take account of all the main players in a complex educational ecosystem [44]. In terms of data and racial bias, it is preferable to develop algorithms based on groups of people rather than on an individual level. According to expert 20, it is more effective to find meaningful statistical differences at the group level and personalise around that information than to personalise down to the individual level. Programming for four or five different groups is much easier and also makes it easier to evaluate outcomes. AI-ALS designers and developers will be better equipped to produce positive education outcomes if they are more willing to think about the different kinds of people their systems serve [45], [46]. In addition, algorithms should be tested to determine how they affect specific groups of people (such as those defined by race and gender) before deployment [47]. Furthermore, members of communities affected by algorithms should be involved throughout the development process and the use of algorithms in education [36], [48].

Finally, the other barrier identified in this study that needs to be addressed is time, financial and other resource constraints, such as poor internet connectivity. Developing and designing AI-ALS involves a lot of investment in terms of time, finances and even human resources (Experts 21, 1, 19 and 2). Moreover, limited time can lead to developers acting negatively, as they "kind of cut corners and so don't necessarily reach the full potential of AI-ALS" development projects (Expert 10). In addition, AI-ALS rely on good internet; hence, poor internet connectivity can limit the implementation of AIEd. Therefore, it is recommended that administrative and financial support should be provided to support AIEd implementation. In the USA, for instance, during the pandemic, there was a major effort to ensure students have the resources to study online. Some students in resource-constrained environments were handed with computers and internet installed in their homes (Expert 14). The State Department also provided teachers with money to purchase online learning systems that helped teach their students during the pandemic. Moreover, the use of existing resources,

such as iPhones, for facial tracking data collection will help alleviate cost and integration barriers (Expert 6). Moreover, collaboration among different research groups and institutions can render the issue of a lack of administrative and financial support (Experts 4, 19 and 18). The above-mentioned recommendations are only a few examples of how AI could help make education more inclusive and accessible.

This study has several limitations due to its nature. The sample population chosen might hinder the transferability and generalizability of the study, given that the author worked with a small sample, who were primarily from developed countries. Thus, given the small sample size of the study, further research should focus on incorporating more perspectives from other experts in the AIED community. Moreover, further research should include more perspectives from experts in developing countries.

6. References

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