ŌTAUTAHI CHRISTCHURCH AOTEAROA NEW ZEALAND
35TH AUSTRALASIAN ASSOCIATION FOR ENGINEERING EDUCATION ANNUAL CONFERENCE
8-11 DEC 2024
THE ENGINEER AND THE WORLD

Equity and the Digital Divide: A Systematic Literature Review of the Integration of AI Education in Primary Schools

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CONTEXT

AI is becoming an important part of society, impacting industry and daily life. To enable students to engage with AI we need to integrate it into their learning. Through early education in AI, we can lay the groundwork for a skilled workforce to develop technologies that enhance sustainable industrial processes and drive diverse representation within the software engineering community.

PURPOSE

This paper undertakes a systematic review of the literature that explores how AI is taught in primary schools. Given the nature of AI to potentially exacerbate inequality, we investigate this literature through an equity lens by exploring the ways AI education is being taught to younger students, how teachers are responding to teaching AI literacy skills, and what is included in various AI curricula. We also examine equity issues in relation to AI education in primary schools, and how these have potential to impact the digital divide.

METHODOLOGY

This systematic literature review is based on the “Preferred Reporting Items for Systematic Reviews and Meta-Analyses" (PRISMA) approach. Of the 27 papers found, the search was finally narrowed down to 15 papers that discussed aspects of digital equity. A qualitative analysis using inductive and deductive coding to identify themes based on the information gleaned from the papers, annotations, and discussions.

OUTCOMES

Several papers identified that AI education is more than learning about the skills and knowledge needed to use AI – it also encompasses an ethical understanding of privacy, data biases and societal issues. While equitable approaches to AI education were not widely discussed in the papers identified, there was some mention of digital access, AI biases, selected representation and language accessibility.

CONCLUSIONS

We found that there is a need for further research to empower primary teachers to establish teaching methods and curricula informed by an equity-based approach so that all students can meaningfully participate in the exciting opportunities offered by AI.

KEYWORDS

Artificial Intelligence, AI Education, AI Literacy, Primary, Equity, Digital Divide

Introduction

The engineering landscape is rapidly evolving with the increasing use of AI, automation, and data analytics. Education needs to be able to respond to the changes in industry and wider society to meet the critical need to develop learners who can understand and adapt to this ever-changing digital world. Deliberate exposure of young children to technologies, like AI, will develop a deeper understanding of how these technologies work and can integrate into various disciplines, including engineering. The teaching of digital technologies will better prepare students to adapt to future changes in the workforce, particularly as engineering tasks increasingly rely on AI tools.

Equity and the digital divide in primary education are themes that play a crucial role in shaping the future landscape of engineering education. Engineering fields have long been dominated by certain demographics, particularly in terms of ethnicity, gender, and socio-economic background. The key approach to address this lack of diversity has been to engage students as early as possible in STEM concepts in the hope of attracting more diversity into the industry (Li et al, 2023). To overcome systemic barriers and prevent a similar lack of diversity in future AI-driven fields, it is therefore important to explore how AI literacy can be developed to engage young learners and support equitable engagement.

This paper provides a systemic review of the literature to identify how AI education is currently being taught to primary school students, aged 5-13 years, and identifies themes that may exacerbate the digital divide. Consolidating knowledge in the field in this way increases awareness of the importance of early exposure to AI education for younger students as a means of ensuring that all students can equitably engage in AI education that will positively shape their future.

Background

Artificial Intelligence in Education

The use of AI in our everyday lives has surged in the last decade with the rise of big data and the exponential growth of computing power (UNESCO, 2022). While many associate AI with robotics (Andries and Robertson, 2023; Kandlhofer et al., 2016; S. Kim et al., 2021; Mertala et al., 2022; Williams et al., 2021), AI has a broader meaning in computer science. It has been defined as “a process enabling a technological tool to make a decision on its own” (Celik, 2023, p.2). Definitions of AI have also evolved and expanded over time to include “machines that imitate some features of human intelligence, such as perception, learning, reasoning, problem-solving, language interaction and creative work” (UNESCO, 2022).

AI in Education (AIEd), refers to the use and teaching of AI technologies to enhance educational practices and learning environments (Owan et al., 2023). This can include AI-driven tools that provide personalized learning experiences, automate administrative tasks, or support educators with data analytics. For example, adaptive learning platforms use AI to customise educational content to suit individual students’ needs, which can improve student engagement and outcomes.

In contrast, AI literacy (AILit) entails possessing the necessary knowledge and competencies to actively interact with AI systems, accompanied by the ability to critically assess their economic, ethical, and societal impacts across different domains (Dai et al., 2024; Long and Magerko, 2020; Ottenbreit-Leftwich et al., 2023). Ethical concerns surrounding AI encompass issues including the privacy of personal data, the presence of bias and discrimination in AI-generated results, and the spread of misinformation (Celik, 2023). AILit equips students and educators with the critical skills needed to navigate an increasingly AI-driven world (Celik, 2023). To utilise AI effectively and ethically, individuals require a certain level of knowledge and skill. AILit should not be a “one-size-fits-all" concept (Celik, 2023); but rather, its effectiveness depends on various factors. Long and Magerko (2020) laid out an interdisciplinary AILit conceptual framework that includes competencies around what AI can do, how AI works, how AI should be used, and how people

perceive AI. This has been adopted by several AI curricula under the broad strands of AI knowledge, AI skills and values and attitudes towards AI (Dai et al., 2024; Relmasira et al., 2023; UNESCO, 2022). Unfortunately, this has not resulted in a broad consensus on the specific knowledge needed by learners in engineering education (Lensing & Haertel, 2020). In particular, the AILit needs of younger students interested in engineering have not been addressed, with existing work focussing instead on the higher education context.

One example of the integration of AI literacies in AIEd is a set of standards for teaching K-12 students in the United States – AI4K12 (Touretzky et al., 2019). The standards emphasise teaching students using constructivist approaches to learn, design, and think creatively to become citizens in the AI generation (Park & Kwon, 2024; Touretzky et al., 2019). The five big ideas covered in the AI4K12 framework are perception, representation and reasoning, machine and deep learning through data, natural interaction, and societal impact (Touretzky et al., 2019). Touretzky et al. (2019) cautioned that it is essential to properly understand AI and that it should be taught to students at a level that is age appropriate. However, in Aotearoa New Zealand and many other countries, AI literacy is not yet integrated into the school curriculum; hence, there remains a need for further consideration. Specifically, the Treaty-driven bicultural context in Aotearoa New Zealand and the potential impacts of AI on indigenous knowledge mean that there is a need for our students to understand both the benefits and barriers of AI in our local context (Clarke, 2024).

Equity to level out the digital divide

Celik (2023) argues that the digital divide is “a significant determinant of AI literacy” (p.8) in general and equity in particular. He argued that AI literacy could be predicted by an empirical model with factors that contribute to the digital divide as the most significant inputs affecting the model. The digital divide refers to the gap between those who have access to digital technologies and those who do not. It is often aligned with socio-economic factors, where children from less privileged backgrounds have limited access to digital tools and education. This hinders their development of essential technological skills, thus intensifying existing social inequalities (Eden et al., 2024; Passey et al., 2018). As AI becomes central to more and more industries, including engineering, ensuring that all children have equitable access to learn about AI will become crucial in reducing this gap.

The digital divide is, however, about more than just *physical* access to technology. Van Dijk (2006) identified four successive types of access to describe the digital divide: motivational, material (or physical), skills and usage. *Motivational access* pertains to an individual’s eagerness and intention to learn, employ, and embrace digital technologies. *Material* or *physical access* refers to opportunities to use technologies, including computers, the internet and software. *Skills access* not only denotes an individual’s capability to learn, utilize, and manage various technologies, but also the ability to comprehend their benefits and challenges, and subsequently choose appropriate technologies for the task. Lastly, *usage access* is where the technology is fully appropriated. Often at this topmost level, people are willing to use, have access to, and know how to operate these technologies.

Research Question

By conducting a systematic literature review, this study unpacks the concept of digital inequality. The study examines **how equity is explored in the literature related to the inclusion of AI literacy within the primary school context.**

Methodology

This systematic literature review is based on the approach “Preferred Reporting Items for Systematic Reviews and Meta-Analyses" (PRISMA). The steps taken to complete the review are described below.

Search Process

Firstly, the scope of this review was defined to be the integration of AILit and AIEd into the primary school space. The lead researcher iteratively analysed related queries when searching through the Scopus database. Scopus was chosen because of its integrated search facility, its curated database and its broad coverage of relevant literature, including journal papers and top-ranked conference proceedings published by Elsevier, Springer, ACM, and IEEE. Search queries were performed based on title, keywords and abstract, and conducted in March 2024. As AI is still growing as a topic, the search was not limited to specific journals or conferences.

After a series of preliminary searches, the research team came together to jointly discuss and revise the outcomes. It was decided to include both ‘AI Literacy’ and ‘AI Education’ as some recent publications included both terms interchangeably. Also, it was decided to narrow the search field to focus on AI education in the primary school context, instead of K-12.

The final query was as follows:

(“artificial intelligence” AND “AI literacy” OR “AI education”)

AND

(“primary” or “k7” or “k-7” OR “young students” OR “elementary”)

The number of records identified after using the search query was n=71.

To begin the screening process, eligibility criteria were established. We included papers published on topics related to AILit and AIEd if they referred to the primary school setting with students aged between 5 and 13 years. Papers that solely focused on a specific AI tool or had no clear links to the primary school setting were excluded. This initial screening excluded 14 papers, leaving 57 papers.

The remaining 57 papers were entered into a spreadsheet and coded as relevant, potentially relevant, and irrelevant. Their eligibility was first assessed by reading their title and abstract. When unsure, the methodology was read to check if the research was centred around the primary school context. Two of the researchers met to jointly discuss the coding outcomes. Where there was uncertainty, the two researchers reread the abstracts and methodology, jointly discussed, and revised the classification. Of the four papers identified as potentially relevant, two were recoded as relevant and the other two were excluded from the search.

This resulted in 27 papers that considered AILit or AIEd in a primary school context. Of these papers, 15 discussed aspects of digital equity as framed in the broader context of van Dijk’s (2006) levels of digital divide. These 15 papers (Andries & Robertson, 2023; Chai et al., 2021; Dai et al., 2020; Dai et al., 2024; K. Kim & Kwon, 2023; S. Kim et al., 2021; Li et al., 2023; Lv et al., 2023; Ng et al., 2021; Ottenbreit-Leftwich et al., 2023; K. Park et al., 2022; Passey et al., 2018; Relmasira et al., 2023; Williams et al., 2021; Zhao et al., 2022), published between 2018 and 2024, form the basis of this review. They consider a range of contexts across China (n=5), USA (n=4), South Korea (n=2), Scotland (n=1) and Indonesia (n=1). The remaining two papers

were theoretical papers that explored conceptualising AI literacy (Ng et al., 2021) and how we can empower equity in and through digital agency (Passey et al., 2018).

Data collection, extraction, and synthesis strategy

The chosen 15 papers were analysed and discussed during regular meetings between the authors of this paper. The purpose of these meetings was to identify the criteria for selecting the papers, to identify themes and to develop a working definition of equity. The data resulted in a spreadsheet with included metadata of the inclusion and exclusion criteria and other annotations. Finally, a qualitative analysis was conducted to address the research question based on the information from the papers, annotations, and discussions. From the papers, we adopted deductive coding, drawing on van Dijk's (2006) four successive types of access to describe the digital divide: motivational, material (or physical), skills and usage. We then adopted inductive coding to identify broader themes that were evident in the literature. The following section explores the themes that have emerged from this coding process.

Findings and Discussion

AI Ethical Issues

In this analysis, AI ethical challenges were highlighted in many ways, most notably regarding privacy and data collection practices. As young learners interact with AI tools in their everyday lives, they may unwittingly share personal information, such as search histories or preferences. Young learners are vulnerable and must be explicitly taught knowledge and skills to responsibly safeguard their privacy in this digital age (Andries & Robertson, 2023; Zhao et al., 2022). Educators and policymakers play a crucial role in ensuring that AI education includes discussions on ethical considerations, empowering students to make informed decisions and protect their privacy rights in an increasingly data-driven world. Teaching AI ethics was considered by teachers to provide powerful opportunities for reflection (Williams et al., 2021).

Equity and the Digital Divide

In terms of equity and digital divide there were four key themes that were addressed across the 15 articles, they were; 1) Access and Technical Barriers, 2) AI Biases, 3) Selected Representation, and 4) Language Accessibility. The next section explores these ideas in terms of how they were highlighted in the 15 articles.

Access and Technical Barriers

The digital divide highlights resource accessibility, which heightens the technical barrier that prevents students from benefitting fully from AIEd (Celik, 2023). Research has shown that students' economic background, geographic location, and cultural background have significant impact on students' access to technological equipment (Lv et al., 2023; Relmasira et al., 2023; Williams et al., 2021). While students often have access to smartphones and the internet (Relmasira et al., 2023), schools in less developed areas have limited curriculum development capacity, hence AI is excluded from many programming courses (Lv et al., 2023).

Another barrier that may intensify this digital divide is motivational access (van Dijk, 2006). In this case, teachers are hesitant to teach because they are not sure of what AI is, how it works, and how it should be used (Kim & Kwon, 2023). Current curricula tend to be built on theoretical frameworks (Long & Magerko, 2020; Ng et al., 2021), and this can reduce the perceived relevance and usefulness for teachers as the frameworks don't always align with teachers' prior knowledge or experiences (Kim & Kwon, 2023). Teachers require substantial resources and support when implementing new and unfamiliar classroom initiatives (Ottenbreit-Leftwich et al., 2023). Thus, to successfully integrate AI into primary curricula, teachers need to be properly supported by coaches and curriculum specialists who can help them overcome steep learning

curves (Ottenbreit-Leftwich et al., 2023). Students may also lack the motivation to learn about AI if they do not connect AI literacies with real-life situations (Chai et al.,2021; Dai et al.,2020).

The digital divide can also be widened by a lack of access to the appropriate skill set (van Dijk, 2006). There are limited professional development programmes for teachers to currently upskill with the necessary AI competencies and teaching skills (Kim & Kwon, 2023). Most courses tend to focus heavily on content and not necessarily on how it should be taught (Kim & Kwon, 2023), especially to younger students. Teachers and students need to be taught the relevant skills and AI literacies in an appropriate way to be able to use AI technologies effectively and critically (Dai et al., 2024; Ottenbreit-Leftwich et al., 2023; Zhao et al., 2022).

Finally, usage access requires a combination of the preceding three accesses. At this topmost level of access, teachers need to create age-appropriate resources and content that will best allow the students to use, have access to, and know how to operate intelligent technologies (Kim & Kwon, 2023; Kim et al., 2021; Long & Magerko, 2020; Williams et al., 2021). A combination of usage time and the diversity of the AI applications in everyday life will encourage students to increase their confidence when using AI (van Dijk, 2006).

AI Biases

Students and teachers alike may encounter biases when using AI in educational settings. These biases can emerge from various sources, including the data used to train AI algorithms, the design of the algorithms themselves, or the context in which AI tools are implemented. For students, biases may affect the personalised learning experiences provided by AI systems, potentially leading to unequal opportunities, or enforcing existing educational disparities (Kim et al., 2021). Teachers may also face biases in the recommendations or assessments generated by AI tools, impacting their ability to make informed instructional decisions.

Additionally, biases may arise from the lack of diversity among developers or the limited representation of certain groups in the data used to train AI models, further exacerbating disparities (Williams et al., 2021). Addressing these biases requires a proactive approach, including critical examination of AI systems, ongoing monitoring for fairness, and efforts to promote diversity and inclusivity in AI development and implementation within educational contexts (Kim et al., 2021; Li et al., 2023; Park et al., 2022).

Selected Representation

Cultural and gender representation in AI technology and AI education is a pervasive issue that can have significant consequences. In many cases, AI technologies have been developed with biases that reflect and perpetuate stereotypes, leading to systems that may favour or disadvantage certain groups of people. For example, male students reported a higher level of confidence, relevance, and readiness for AI than female students did (Dai et al., 2020). Moreover, the lack of diversity among AI developers can result in products that overlook the perspectives and needs of diverse groups.

Young students were reported to overestimate the capacity of AI and were typically unaware of the human biases in AI decisions (Dai et al., 2024). Li et al. (2023) noted that students in Grades 3 to 5 had not yet developed a gendered view of occupations and recommended that gender-inclusive programmes are “crucial for underrepresented students at an early age before gendered views on career fields take root” (p.577). To address these challenges, it is crucial to promote diversity and inclusivity in AI development and education, to ensure that everyone has equal opportunities to learn about and contribute to AI technology (Kim et al., 2021; Li et al., 2023; Park et al., 2022). For example, where a diverse group of teachers worked together to teach AI, students experienced positive impacts on their sense of belonging (Williams et al., 2021).

Language Accessibility

An important consideration is the impact of different languages on digital content, particularly the dominance of English and the limitations of translation technology (Passey et al., 2018). Proficiency in English is becoming increasingly vital for equitable access to online resources

(Passey et al., 2018; Williams et al., 2021). More work needs to be done on translation work, where the translations are not just done word-for-word, but instead to include richer cultural metaphors that resonate with the students (Williams et al., 2021).

Conclusion

This systematic literature review explored the ethical considerations around the integration of AIEd into primary settings. Key concerns were how privacy can be respected and how data collection is conducted. It also explored equity issues in terms of access barriers and the digital divide. These issues included AI biases, selected representation, and language accessibility.

AI-based learning experiences that focus on creativity, problem-solving, and real-world applications can engage a broader range of students, particularly girls and students from underrepresented groups, in engineering-related subjects. These early experiences can level the playing field by challenging stereotypes, building confidence, and inspiring a sense of belonging in fields such as AI and Engineering, encouraging a more diverse range of students to pursue these careers. Starting AI education early ensures that students learn not just how to use technology, but also how to critically evaluate its impact and responsibly design systems that benefit society as a whole. In Engineering, this is essential for creating a future workforce that values diversity and is committed to solving problems that positively impact all communities.

Moving forward, there is a need to conduct research into AIEd in Aotearoa New Zealand, so that we can explore the impact of AILit on our bi-cultural education system and better understand bi-cultural experiences with AI technologies to develop inclusive frameworks that prioritise equity. Ensuring that AI becomes a focus in the Aotearoa New Zealand curriculum and facilitating the implementation of inclusive AI strategies that mitigate rather than exacerbate existing inequalities will require fostering collaborations between academia, industry, and policy makers.

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Acknowledgements

We thank the University of Canterbury for providing the UC Aho Hīnātore | Accelerator Scholarship to fund this research.

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