The Impact of Artificial Intelligence in Education and its Effect on Student Learning

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On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

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Introduction

The current educational environment is experiencing rapid development with the inclusion of technologies such as learning management systems, digital devices, and widespread online resources such as massive open online courses (MOOCs), significantly altering the ways in which teaching and learning take place (Selwyn, 2014). With the introduction of these digital resources, they have shown promising advantages in education, with student engagement levels increasing due to more tailored learning through computer technology in curriculums (Carsten, 2021). Part of the drive to use new technologies to improve student education is the integration of artificial intelligence (AI) in the classroom, with an expected annual growth rate of 48 percent per year over a four year period from 2021 to 2025 (Zhang, 2021). In its integration into the modern classroom, AI has seen itself introduced into fields such as personalized learning, intelligent tutoring systems, automated assessments, and collaborative learning environments (Bulathwela, 2021).

AI systems in education are built off of techniques such as machine learning algorithms and natural language processing to process large amounts of data created when updating material introduced to students based on their individual needs, preferences, and performance (Baker & Inventado, 2014). Building off successes in areas such as personalized tutoring bots for student use (Bulathwela, 2021), a decreased burden for educators in identifying student emotional issues within the classroom (Xie, 2022), and statistically observable increases in exam scores in large scale student assessments (Luckin et al., 2016), artificial intelligence has shown evidence backed results in improving education from the perspective of students, educators, and institutions alike. An increased reliance on technology in the classroom has not been met with unilateral enthusiasm, however.

Pressing risks to using AI in the classroom that have been brought up in educational research include invasive student data collection during interaction with AI applications (Zeide, 2017; Cukier et al., 2019). These risks do not stop at students, however, as educators may be given new expectations and guidelines in how they teach the classroom using AI including an increased focus on student wellness and student management techniques employing the new informatic tools available at their fingertips (Luckin et al., 2016). Further issues arise for educational institutions at large across the United States and worldwide with the potential for greater educational inequality across different countries (Bulathwela, 2021) and an introduction of programmers' bias in released software (Zanetti, 2019).

With the growth of artificial intelligence still in its infancy and without a clearly defined framework or regulation for widespread implementation (Bulathwela, 2021), the educational system is at risk for being exposed to unintended negative consequences including decreased student privacy, raised inequality and the introduction of more bias in education material, and an alienated workforce of teachers unable to use AI tools that they are not properly trained in. Therefore this paper aims to show that AI in education has a strong basis for improving the field of education for students, educators, and institutions alike, but needs a more clear and structured approach in its implementation to mitigate pressing risks that may compromise its efficacy.

To support the primary assertion of this paper, an investigation on the effects that AI has on relevant social groups within educational structures is carried out through the Social Construction of Technology (SCOT) STS framework. First described in the 1984 paper "The Social Construction of Facts and Artefacts," the Social Construction of Technology (SCOT) STS framework explains that advancements in technology are shaped by the needs and actions of relevant social groups, in contrast to the concept of technological determinism, in which

technology itself determines human action (Pinch & Bijker, 1984). Well suited to describe the intricate web of relevant social groups in the field of education, this paper defines these relevant groups as students, educators, and educational institutions.

Methods

This study performs a systematic literature review into the field of artificial intelligence in education with the rationale of validating the assertion that applications of AI have sufficient evidence to in general benefit the field of education, with the exception that considerable obstacles exist in justifying an immediate large scale integration into educational programs. To perform this research, inclusion criteria for studies specifically pertaining to studies on education, artificial intelligence, or their combined effect. The literature review is primarily sourced from published journals, with a focus on education and AI journals including those such as *The Institute of Educational Sciences* and *Artificial Intelligence Review*. Relevant conferences are also included in this review, including *The Proceedings of the 39th Annual Hawaii International Conference on System Sciences*. Given the pace of publishing within these fields, studies will be included within fifteen years of this paper's writing. One exception is a citation from the Harvard Business Review, which provides explicit statistics on the percentage of companies currently adopting and prioritizing AI technologies in their investments.

Of additional important note is the contained focus of studies that originate from the United States, China, and western Europe. While not intentional, the vast majority of papers reviewed originate from these three areas due to the importance of the intersection of AI and education within these groups. Limitations from the scope of this dataset may give decreased

relevance of this study on regions outside these areas that employ different systems and cultures of educational development.

In performing a literature review, this study is divided into two key parts. The first investigates the development of and present conditions in AI in education, giving a background to how AI has already positively impacted the educational field with currently implemented technologies as well as how observed issues relating to AI have begun to percolate and come to the attention of researchers, the media, and educational experts. The second part of the study delves into defined relevant social groups, giving the benefits these groups have already seen and may continue to see that are inherent to their unique group. Following these benefits, pressing concerns related to AI are introduced for that social group that may harm them and should be addressed to ensure a healthy relationship with AI.

As with other technologies that have stood the test of time, uncertainty in how AI will develop and affect society will instigate strong responses both for and against its use. With the seemingly unlimited potential of AI expected to bring about massively transformative alterations across aspects of society varying from the labor market, healthcare, and the economy (Chui, Manyika, & Miremadi, 2016), it is difficult to predict exactly what those effects will look like. As AI technologies continue to evolve, their impact on society will likely become even more profound, raising important questions about ethics, privacy involved, and related policy development (Bostrom & Yudkowsky, 2014). As such it is important to note that this field is subject to rapid change, and the evolving relevance of this review should be noted as such.

Literature Review

Part 1. Education and AI: From Research to Implementation and the Ensuing Response

While being a subject of academic research for over 40 years, the advent of advanced machine learning algorithms, natural language processing, and increased accessibility of computational resources have only brought it to the foreground of public interest after the turn of the 21st century (Luckin et al., 2016). Met with high optimism, many research experts have responded positively to its growth. In a 2021 volume of the journal *Computers and Education: Artificial Intelligence*, learning design and technology professor Ke Zhang highlights the potential for AI in education as having "promising potentials to provide customized learning, to offer dynamic assessments, and to facilitate meaningful interactions in online, mobile or blended learning experiences" (Zhang, 2021, p. 1).Furthering this enthusiasm, educational and computer science expert and UMass Amherst professor Beverly P. Woolf suggested that AI-driven intelligent tutoring systems could "revolutionize education" by facilitating "deep, long-lasting learning, motivation to learn, metacognitive skill, and robust transfer of learned skills and knowledge" (Woolf, 2009, p. 184).

Outside of intelligent tutors, implemented AI technologies in the classroom have included natural language processing (NLP) tools that can assess written essays and prompt responses from students to score and provide tailored feedback on their performance. Seen as a means to reduce educator workloads, as drawbacks for manual grading include time to complete and a lack of consistent reliability among different teachers (Ramesh, 2021), the development of automated essay scoring (AES) using NLP has been investigated as an improved alternative. In a 2023 study, the implementation of a large scale AES system on 600 students delivered an initial 90 percent accuracy with several different AES agents scoring the same essays, and a high Kappa Level of 0.67 for the comparison of AES scoring compared to an average of several human graders (Lee & Tan, 2023). Initial results have been positive, with shown benefits in

"providing formative feedback to students", though ceded that there "exist significant challenges for researchers in implementing automated essay grading systems" (Ramesh, 2021, p. 2,527), showing a need for future advances to enter classrooms as a staple technology.

Keeping these benefits in mind, as AI technologies have been implemented in educational settings outside of research, a more nuanced understanding of their impact and critical reception to them has emerged. While the potential advantages of AI remain significant, researchers and educators have begun to highlight more of their potential drawbacks and limitations. One particular concern that has been raised is AI's effect on educational equity, as access to AI-driven educational resources and tools may be limited for students from underprivileged backgrounds (especially those in developing nations), only further exacerbating existing levels of student achievement across varied backgrounds (Bulathwela, 2021; Reich, 2019).

In tandem to raising inequality, there is also a growing awareness of the ethical and privacy-based concerns related to the use of AI in education, particularly in regards to the collection and analysis of student data (Zeide, 2017; Cukier et al., 2019). AI systems often rely on large datasets to properly function, which may include collecting and analyzing sensitive student data (Zeide, 2017). The handling of such data may lead to significant breaches in privacy at the severe detriment to students and their respective institutions (Cukier, Ng, & Nesselroth, 2019). With these concerns in mind, this has led to public calls for increased transparency in data handling, manufacturer accountability, and legislation for the regulation of AI technologies in educational contexts (Selwyn et al., 2019).

With both the advantages present and the concerns of certain fallbacks, AI in education has become a much discussed field of development with vocal supporters and opponents in

popular media and in vetted academia. In the current climate of rapid technological evolution and aims to improve educational standards while still keeping inequality and privacy in check, there is significant value in a careful analysis of the SCOT framework in reference to this evolving technology. Through the discussion of benefits, risks, and suggested steps for moving forward, it is the goal of this paper to provide a starting direction in creating sustainable AI technologies for improving education under a clear direction of steps and approved legislation.

Part 2: Use of the SCOT STS Framework to Study Affected Social Groups

Education is continuously evolving, and with the advent of mass produced, easily accessible technologies, this pace is only accelerating. Since the 1960's, computing technologies have been dominated by expert systems that employ manually coded decisions written by programmers that are incapable of evolving output in response to varied user inputs (Mijwil et al., 2022). Driving the current computing revolution is machine learning based artificial intelligence that is built off of large datasets responsive to the specific interactions it has with the user. With this shift, educational settings may become significantly altered, requiring teachers and institutions to adapt their teaching methods to best employ these new technologies and stay relevant within the educational sector. Apart from a change in teacher roles, students may also be expected to become fluent in these technologies and adjust to a less human and more computer based instruction.

To gain further insight into the changes the adoption of AI technologies in the classroom will bring, the Social Construction of Technology model is used to identify key relevant social groups around the AI and education artifact, with relevant issues branching from each group. As stated before, these relevant groups can be defined as students, educators, and institutions, as

additionally shown in the graphic model depicted below in Figure 1. Each of these group's interpretive flexibilities, which is best defined in relation to Pinche and Biljker's original paper as the interpretation of an artifact (AI in education) through the lens of that group's lives and goals, will help create an understanding of how their needs shape the future development of this cutting edge technology. As sentiments have already begun to develop in first generation developments of AI technologies, it is important to understand how these sentiments are projected to change with future AI iterations, and how this may significantly change the direction of public policy even over a relatively short period of time.

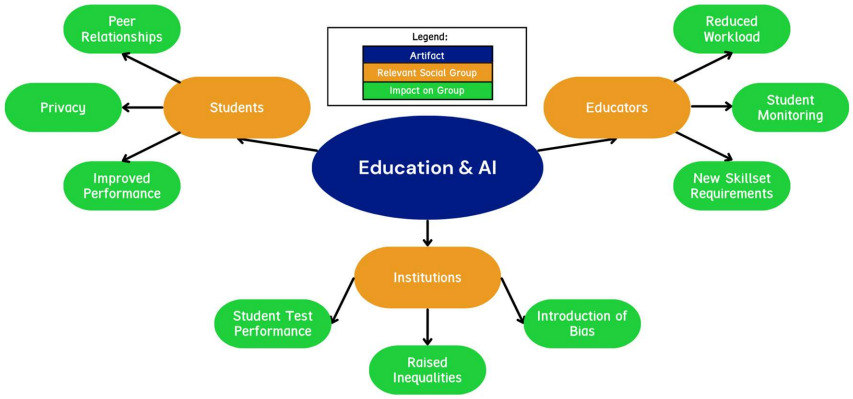

Figure 1: SCOT Model for Education and AI, showing relevant social groups and their impacts

Effects on Students

With new AI tools arriving into the market for consumer use from major companies ranging from Google Workspace to Bing search enhancement after the popularity of ChatGPT, a clear shift can be seen in tech company priorities shifting to advancing AI. As many as 52 percent of companies have placed advanced efforts on adopting AI technologies since the onset of Covid-19, with 86 percent of companies seeing it as a mainstream technology (Harvard Business Review, 2021). With this in mind, students are shortly set to be exposed to widely

available AI technologies that can assist them in completing their coursework. Benefits with high potential for students include writing assistance through feedback on papers, including assistance with “sentence structure, grammar, vocabulary, punctuation, citations, and plagiarism” (Bahrini et. al, 2023). With the use of ChatGPT and popular computer programming assistant GitHub CoPilot, students have the opportunity to generate simple computer programs and check the accuracy of their code, significantly decreasing debugging times.

Beyond assistance in improving the quality of submitted work, students can benefit from the introduction of intelligent tutoring systems (ITS) into their curriculum, which provide individualized feedback and guidance to students as they work through problems or tasks (VanLehn, 2011; Zhang, 2021). Results with ITS have been promising, with students using intelligent tutors outperforming those who did not in 46 studies out of a sample of 50, with scores 0.25 standard deviations above the average in 39 studies (Kulik, 2015). In a separate study, intelligent tutors were found to additionally assist elementary aged students in learning new science content in traditional classrooms outside of the AI software (Chin, 2010). Successful applications of AI tutors have included increased test preparation for individual students, in which an adaptive quiz system uses reinforcement learning based on what topics a student does and does not perform well on. Compared to traditional techniques such as gamification of learning topics, a 2022 study found a 12 percent decrease in time taken to learn new concepts and a 15 percent greater post improvement in assessment scores (Sayed, 2023).

While student performance and task efficiency has seen clear improvements, several threats to students surround the personal use of AI learning technologies. One present issue is the impact of AI on student privacy and data security. AI systems often rely on large datasets to function effectively, and this may involve the collection and analysis of sensitive student

information (Zeide, 2017). The handling of such data raises ethical questions and may lead to potential misuse or breaches in privacy, which can have significant consequences for students and institutions alike (Cukier, Ng, & Nesselroth, 2008). In an effort to avoid legal consequences, companies offering AI services to students frequently require express consent to access their data, which can include details such as "the language spoken, racial identity, biographical data, and location" (Akgun & Greenhow, 2022, p. 434). Frequently unaware of the extent data is shared and effectively forced to use the software in classroom settings, privacy remains a clear risk that lacks sufficient legislation to currently protect.

Further issues exist around social impacts, in which the relationships students build with peers and teachers are detrimentally affected. By limiting face-to-face interactions, students face less motivators to improve social adaptability, preventing improvements in social anxiety that come through exposure to their peers (Ali, 2020). In addition to the systems of AI delivering more instant feedback, surveyed students expressed concerns that independent learning skills would be diminished due to an overreliance on AI in scenarios that previously called for more self-led research (Seo, Tang, & Roll, 2021). Building on the reliance on AI, a significant grievance lies in AI based proctoring systems that monitor student's screens while taking online exams. Complaints from students using the popular proctoring software Proctorio express that they become "hypersensitive" to actions such as eye movements that can be perceived as cheating, which leads to less attention given to exams and more to not "seem suspicious" (McArthur, 2020, p. 1).

Effects on Educators

Educators play a key role in the implementation of AI in the classroom, contributing to the development of AI technologies in education by sharing their expertise and feedback, helping

AI systems become more effective teaching tools (Graesser et al., 2018). Even with AI taking a larger role in the classroom, teachers act as a common executor of these new tools, being responsible for deciding when and how to use AI technologies for their students (Luckin et al., 2016). In a collaborative study with educational publishing giant Pearson's Open Ideas Initiative, Dr. Rose Luckin suggests that the development of educational AI tools should be a "participatory design methodology", to "ensure that the messiness of real classrooms is taken into account and that the tools deliver the support that educators need" (2016, p. 31) in contrast to what technologists and designers who don't take an active role in teaching may assume. This belief strongly impresses upon the SCOT framework, taking insight from relevant social groups in the education sector to directly create what can be a uniquely helpful tool.

Perhaps the clearest benefit to educators will be the ability to assign repetitive and time consuming tasks to AI assistants. Post instruction duties such as evaluating assessments and essays, which in a US Department of Education study was shown to take at least an hour of work per day for 36 percent of teachers, may in the most part be able to be tackled by AI software (McShane, 2022; Seo, 2021). Tied in with the reduction in assessment time burden is quicker identification of gifted and struggling students through visualization tools and progress monitoring (Graesser et al., 2018; Zhang, 2021). By giving students more autonomy in their education and letting educators spend less time on repetitive labor, educators specifically in the realm of younger students are given the opportunity to focus on more human aspects of teaching such as social integration, dealing with frustration, and resolving conflicts (Luckin et al., 2016). As several leading studies show and promote human influence along with AI technologies, job displacement appears as a low concern, however educators face the issue of needing to update

their teaching methodologies or risk becoming improperly experienced and obsolete (Zhang et al., 2021; Luckin et al., 2016).

As with the introduction of any new widespread technology to a job sector, new training and educational programs will be required. To use AI tools effectively, Dr. Luckin suggests key actions including:

- Proper comprehension on how AI can be used to assist in learning across a field of scenarios so that specific AI technologies can be properly chosen.
- Updated management skills that take into account research techniques interpreting data feedback from AI systems that point to insights from their unique classroom environment.
- Determination of repetitive tasks that can be assigned to AI agents in exchange for the opportunity to focus more on human relational activities such as student mentorship, interpersonal skill development, and emotional support.

Building on this, background AI monitoring of student issues will give teachers new tools to detect social issues that may have previously required manual detection methods such as surveilling students and relying on voluntary feedback from surveys (Seo et al., 2021). Teachers then will be expected to understand how to intelligently take this collected data and use it to hone in on students in need of further emotional guidance and connection to social resources outside of the classroom.

Effects on Institutions

The implementation of AI technologies lies primarily in the hands of administration and leadership directing the decision making process of educational institutions. As institutions must weigh several factors in choosing new technologies for delivering the best quality education for

the most students, wide scale adoption of these discussed technologies becomes a complex process that requires a careful traversal in the realm of ethics, budget, and performance. In her 2021 paper "Could AI Democratise Education? Socio-Technical Imaginaries of an EdTech Revolution," Sahan Bulathwela from University College London's Centre for Artificial Intelligence proposes a set of responsible foundations for implementing AI technologies at the institutional level. These foundations aim to broaden access to opportunities, improve health, bolster the resilience of communities and institutions, drive long-term economic growth, reduce poverty, and spur innovation (Bulathwela, 2021). Keeping her proposed pillars in mind, this section aims to investigate the potential effects of an unstructured implementation of AI in educational settings and in the next section compare it to a suggested model for alleviating potential introduced inequalities and promoting “empowering access to education … beyond any barriers”.

One of the most straightforward benefits that has been identified is large scale improved test performance for student groups. An analysis of studies of intelligent tutors across 50 papers published amongst four continents found that in 46 studies, students who used intelligent tutors outperformed control groups. In 39 of these studies, the test score increase was over 0.25 standard deviations, marking a statistically significant improvement (Kulik & Fletcher, 2015). As test scores play a significant factor in whether schools maintain funding based on their Adequate Yearly Progress (AYP) standards and can determine whether school districts deliver larger bonuses to teachers (US Department of Education, 2009), institutional administrations are highly motivated to raise student performance levels. By improving the work quality for educators through decreased teacher burden and decreasing the high 16 percent yearly teacher turnover rate

in the US, institutions are able to simultaneously draw in more potential talent and save on budget for the hiring process (Bryant et Al., 2020).

Even with the promising budgetary benefits for institutions, serious risks for perpetuating discriminatory practices remain. A well known issue in AI models is the implicit bias present within the databases they are built off of, stemming from the personal preferences, beliefs, and backgrounds of their developers (Hrastinski et Al., 2019). These biases can present issues such as reaffirming unequal power structures in gender through stereotypes built into used languages (Johnson, 2021) and datasets and racial misidentification in similar datasets of "African American and Latino American people as convicted felons" (Murphy, 2019, p. 435). Additionally, models are commonly built off of European languages, with available translation models having low quality "far from the needed quality for learning purposes, where translation and transcription errors can easily impair the learning experience" (Bulathwela, 2021; Perez-Ortiz et. Al. 2019).

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Outside of the context of the United States, the issues regarding institutions can be seen on a global scale, amplifying inequalities between developed and developing countries. Current AI models are not designed to work with low resource settings where less advanced digital devices and infrequent internet connections are common (Fyfe, 2016; Wulczyn et Al., 2017). This lack of access presents the issue of leaving groups in critical need of improved educational devices out of the advantages AI in education may present. Given the benefit that AI in education can present for accessibility, and with over 80 percent of the world's disabled population living in developing countries (Global Disability Innovation Hub, 2021), the pressing need for institutions to have access to AI technologies that can improve accessibility becomes even more crucial in currently technologically underrepresented countries.

Conclusion and Future Steps

The application of AI in education has promising prospects, with observable benefits present for the key social groups affected by the development in this field of technology. Current implementations of AI in education including automated essay scoring, intelligent tutors, and computer programming assistants have already seen demonstrated success in real world classroom applications. Furthermore, wide scale studies strongly suggest improvements in student test scores and improved efficiency in individualized teaching, giving educators the opportunity to adjust priorities in nurturing student social development without sacrificing the extent of educational content covered in the classroom. With decreased burden on educators to perform repetitive tasks such as grading and the opportunity for institutions to increase funding with improved student performance, it is the author's assertion that AI should be prioritized as a means for improving student education due to the clear advantages it has presented.

With these advantages however follows the clear risks that AI in education presents in its current state. For students, privacy remains a significant issue when AI technologies collect large amounts of data that involve personal information. Students are also at the risk of impacted social development, with the potential for decreased in peer to peer interactions and introduced stress in AI proctored testing environments. Educators face a significant shift in pedagogical techniques due to the role AI may take that previously required significant time and effort on the part of the educator. With a shift in priorities and the learning curve for understanding AI technologies, educators face the dilemma of updating their teaching methods or facing poor qualifications for their roles. Institutions, perhaps faced with the largest responsibility, must exercise diligence in ensuring bias and inequitable access to these technologies do not

detrimentally impact the quality of student education both on a national and global scale. These risks present significant obstacles and concerns regarding the fast pace at which AI in education is being implemented. It is therefore of utmost importance that these factors be studied and resolved through careful policy and research before widespread implementation is attempted.

By taking a close look at the development of AI through the SCOT theory, an understandable model can be made to identify how the needs of each relevant social group in part affects the future development of this technology. Uncovering the impacts of AI in education on each of these stakeholders helps provide insight into intelligent and responsible policy to maximize student success of varied backgrounds in a manner that alleviates educator burdens and boosts resources for administration to perpetuate institutional development. Taking a background from the Unesco Education Sector's Working Papers on Education Policy project (Pedro et Al., 2019) and Sahan Bulathwela's "Proposed Pillars for AI in Education", the collaboration between AI experts and educational policymakers has led to a strong call for policy to ensure:

- Open source initiatives to build a common database of free to access educational resources from a variety of diverse backgrounds.
- Language-agnostic or easily translatable knowledge sources such as Wikipedia upon which to design new AI tools.
- Collaborative and transparent AI algorithms designed to give the maximum opportunity to end-users to control and modify their use of AI based tools and software.

The main call across proponents of AI reform for social change, particularly in the domain of education, is a foundation in open-source resources. Through the collaboration of publicly funded projects under national or global policy, codified to ensure quality and accessibility, large

scale sharing of AI technologies is an achievable goal that can be used to promote universal education and invest in teaching the next generation. Apart from public policy, techniques can be adopted from current open source projects such as Wikipedia, Linux, and GitHub, which have successfully dispersed large amounts of information through democratic means. Given the largely private sourcing of AI technologies from individual companies, this remains a roadblock that would require significant investment to overcome.

With the accelerating rate of AI technology adoption in the 21st century, a wide array of industries, organizations, and institutions are going to experience massive amounts of growth at the possible expense of privacy, equality, and social connectivity. It is therefore imperative to understand stakeholders in each of these fields and navigate the developments that will ensue from each of their priorities as these technologies progress. Taking these factors into account, AI in education has the opportunity to bring about significant positive change for students, educators, and institutions alike, and usher in a new generation of societal growth.

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