AN LED ASSISTED CHESSBOARD FOR USE AS AN EDUCATIONAL TOOL
(Technical Project)

ARTIFICIAL INTELLIGENCE, CHESS, AND THE FUTURE OF EDUCATION

(STS Project)

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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

As the last children to have seen the world before the turn of the twenty-first century age into adulthood, we are approached with a generation of digital natives. As early as the age of seven years, children have been found to have equal levels of literacy in reading from computers, smartphones, and printed sheets (Yadav, 2022). The introduction of digital resources has shown promising advantages in education, with student engagement levels increasing due to more tailored learning through computer technology in curriculums (Carsten, 2021). An increased reliance on technology in the classroom has not been met with unilateral enthusiasm however, gaining a reputation for leading to poorly developed student social skills (Singer-Califano, 2008). As educators search for new ways to promote student learning and social development, the application of artificial intelligence to teaching methods has become popularized and seriously evaluated, with an expected growth of 48 percent in the education sector over a four year period from 2021 to 2025 (Zhang, 2021).

Building off the success seen in personalized tutoring bots (Bulathwela, 2021), improved social adaptability (Ali, 2020), and decreased burden for teachers in identifying student emotional issues within the classroom (Xie, 2022), artificial intelligence has shown observable results in improving student education. Issues arise however with the potential detrimental effects of artificial intelligence, including a potential for greater educational inequality across different countries (Bulathwela, 2021) and an introduction of programmers' bias in released software (Zanetti, 2019), and dealing with student desires for face-to-face interactions (Holstein, 2019). With the growth of artificial intelligence still in its infancy and without a clearly defined framework or regulation for widespread implementation (Bulathwela, 2021), it is important to investigate the current and potential effects that artificial intelligence has on relevant social groups. To this end, I aim to answer the STS question: “What are the social impacts of artificial intelligence in education and what effect does it have on student learning?”.

With the increased comfort in a digital landscape has come the decline of physical media that have been replaced with their digital counterparts, for reasons of accessibility, features, and cost. One field that has been particularly involved with this revolution is playing board games. Since the defeat of chess grandmaster Garry Kasparov to IBM’s famous Deep Blue computer in 1997 and the release of the popular chess playing software “The Chessmaster 2000” in 1986 (Edwards, 2013) for personal computers, the potential of computer chess became realized and reached massive levels of popularity. The popular online chess server Chess.com sees nearly 17 million monthly active users (Keener 2022), attesting to how successfully the board game has been integrated into the computer realm.

With the advantages of digital media based board games made apparent in their recent popularity, it brings the question of whether anything is missed from the prior use of physical boards and pieces. From the tactile sensation of sliding a pawn towards the king in a game winning blow to the dynamics of moving pieces and slapping a timer during speed chess, there are certain elements to the game that are difficult to reproduce within the current limitations of a two dimensional screen. Additionally, there is an aesthetic appeal to wooden pieces and the desire to have a set to bring out for guests at an event or simply to have for display. Senior users not accustomed to the dynamics of computer software and young children not yet able to fully read or type may be discouraged from using digital platforms for playing board games and therefore miss out from their improvements. A new question comes into mind in how the advantages of artificial intelligence assisted software and the sensation of real pieces can be combined in one application. To this end, my technical project aims to create a smart chessboard that answers the technical question: how can artificial intelligence algorithms be implemented into physical hardware to produce smart board games that improve user satisfaction rates?

Technical Project

The AI powered chess board is an interactive board game intended to bridge the assistance of machine learning based algorithms to players using a physical board. Belonging to the Internet of Things (IoT), the chess board will help those who are uninitiated in chess to learn how the game works and to further the progression of players who want to enhance their gameplay. It can track the location of each unique chess piece using sensors on the board, and relay that information to a chess engine on a personal computer (PC). The engine will calculate a recommended move and signal to the chess board to light up squares corresponding to the engine's recommendation. The smart chessboard will serve as a learning tool for chess players of all skill levels and have options to calibrate the strength of the engine to meet each player's needs.

The concept of an assistive chess board is widely available from a multitude of different companies. The most prominent chess board, named ChessUp, is made by Bryght Labs. This physical board can wirelessly communicate with the chess playing website chess.com to light up the chess tiles based on capacitive touch to show the player the best location to move their chess pieces. This board can also interface with an artificial intelligence engine and wirelessly keep track of the chess pieces on the board. It can signal which move is a good move, a blunder, or a perfect move based on the configured strength of the AI. Another project, based in the state of Illinois, used the strength of the magnet to determine each unique piece on the board (Kaufman, 2017). They also used light emitting diodes (LEDs) on the board to determine which moves the piece could make, similar to the board made from Bryght labs.

Based on the projects already created, the differentiating factor our project presents is using binary encoding to identify each chess piece. Existing projects have used capacitive sensors or relied on the strengths of magnets to identify their chess pieces, but this often results in a lack of reliability for piece detection (Coven, 2017). One project, which used linear hall effect sensors and different magnets strengths for each piece was only able to achieve 80% reliable piece recognition (Muji, 2016). By using digital hall effect sensors and binary encoding, we aim to produce a very reliable smart chess board that works 100% of the time. Digital hall effect sensors will be more reliable because they only need to detect the presence of a magnet, but don't need to consider their strength (Rolink 2022). An additional improvement with the design is the relatively low cost of the design that take advantage of cheap sensor and LED components in comparison to the more expensive solutions built on wireless technologies.

In the creation of the artificial intelligence assisted physical chessboard, a case study of the STS project can be made with an investigation of how using the board improves player learning compared to standard chess software online. Furthermore, the board can be used to better understand how groups more unfamiliar with digital platforms such as very young children can still take advantage of artificial intelligence techniques for improving their learning. In conjunction, results from extensive literature review on the benefits of chess instruction transferring to academic and cognitive skills (Sala, 2016) gives a direct means of measuring how these skills change when chess instruction is delivered with the integration of artificial intelligence. The culmination of these factors makes the proposed chess board a useful tool in understanding how much of an influence artificial intelligence has on student learning methods.

STS Project

The integration of computer technology into schools has had a profound impact on the methods of student education, improving engagement through the ability it gives for students to tailor their learning (Carsten, 2021). As implementations of machine learning algorithms improve, there has been an increased interest in using artificial intelligence (AI) to improve the quality and accessibility of education. One particular demonstration of this technology are intelligent tutors, built to provide students with materials tailored to their learning needs and return feedback unique to their performance (Zhang, 2021). Results 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).

Further benefits have been shown in social adaptability, overcoming concerns related to decreased face-to-face communication with the rise in electronic devices in classrooms (Halpern, 2017). AI based technologies in classrooms have hinted at an opposite effect, improving child creativity when interacting with social robots and decreasing loneliness by creating a better way for teachers to understand student needs and communicate with them (Xie, 2022). While these results prove promising for advancing pedagogical techniques, there are a number of significant risk factors and potential downsides that may prove detrimental if these AI techniques are implemented without proper foundations in policy and open source creation. In Sahan Bulathwela's "Could AI Democratise Education? Socio-Technical Imaginaries of an EdTech Revolution", Bulathwela gives a thorough investigation of the potential for AI in education to aggravate societal inequality and lead to improper distribution of educational resources.

Bulathwela's work and discussion will be drawn upon to carefully answer how AI may impact relevant social groups in education and what techniques can be used to mitigate potential downfalls.

The current state of AI in education rests largely in the field of research, largely without a clear and unified foundation for its execution. Given the wide array of actors contributing to the creation of AI in education such as private companies and public researchers, there is a large susceptibility to present bias in different softwares (Bulathwela, 2021). The International Development Innovation Alliance has further addressed issues in transparency and access to data of unilateral quality for scaling these technologies to different nations (IDIA, 2019). In response to these obstacles, potential solutions include the use of open source software free for access across different actors and the use of a standard knowledgebase so that users of different backgrounds learn from the same source of content (Bulathwela, 2021). As it has been discussed outside the scope of education, AI is susceptible to breaches of privacy, which become a concern for students supplying personal data in educational algorithms (Zhang, 2021).

With the array of present advantages and concerns, it is useful to apply STS models to understand the relevant social groups affected and potential methods for improving outcomes for AI in education. To this end, the development of these technologies will be visited through the Social Construction of Technology framework described by STS academics Trevor Pinch and Wiebe Bijker in their 1984 paper "The Social Construction of Facts and Artefacts". The Social Construction of Technology (SCOT) 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 and Bijker, 1984). In the realm of AI in education, the relevant social groups can be defined as students, educators, institutions, and researchers that work together to create and respond to developments in this technology. To understand how these actors are involved in the creation and modification of AI in education, Bulathwela's paper is investigated to understand how much power is currently placed in the hands of each of these stakeholders.

Research Question and Methods

In my paper I aim to answer the STS question: what are the social impacts of artificial intelligence in education and what effect does it have on student learning?. In order to answer this, a literature review of educational programs and studies that have integrated AI devices such as intelligent tutors, personalized learning environments, and educational games will be investigated to create an outline of techniques used and their reported efficacies. Efficacy will be measured by the number of papers within a specified sample size that report positive or negative impacts on a certain factor such as increased student involvement or difficulty in setting up software. A potential limitation of this method may be a bias towards positively showing the effect of artificial intelligence in these studies, requiring further research into alternative papers.

Additionally, I aim to answer the technical question: how does the use of an artificial intelligence assisted physical chessboard improve player satisfaction compared to playing chess on traditional software alone? A study will be performed in which participants play part of a game on the completed artificial intelligence assisted chessboard and then play part of a game on the popular chess site Chess.com against a bot. Participants will then be asked to rate their experience on a field of criteria to gauge their satisfaction and engagement with both the physical board and the online game. Demographics in the survey will attempt to be spread over a wide array of ages and chess skill levels to assess comfort with using physical pieces vs clicking controls when playing on a website. This would provide useful information on the value users place on playing on a physical board, particularly those who aren't as comfortable with the use of a computer.

Conclusion

The technical deliverable for the capstone project will be a completed artificial intelligence driven physical chess board along with the results and analysis of the survey investigating ratings of comfort and satisfaction with the product compared to online methods. Results from this study will help develop an understanding on the value society places on physical media and how it can be updated to reflect the growing popularity in digital media through artificial intelligence. Furthermore, investigating how the inclusion of AI in teaching structures affects students and the roles of teachers and institutions can provide insight into how student learning and social development can be individualized to create tailored solutions to their education while avoiding potential pitfalls in bias and inequality. Through a literary analysis that takes advantage of the SCOT framework and looks through the frame of Bulathwela's socio-technical imaginaries, it is the hope of this paper to provide some foundational research for developers to work with educators and sociologists to create holistic solutions to producing useful and responsible AI.

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