Robots in Schools: How Innovation Attempts to Solve Problems in Education

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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:

Now more than ever, teachers in the United States are quitting their jobs. This is due in part to the increase of school violence, burnout, and the pandemic introducing extreme challenges to the teaching profession, and the "[American] public education system was not built, nor prepared, to cope with a situation like this" (Garcia, 2020). Systems with the goal of supporting teachers, students, and administration face unprecedented difficulties; however, technology has been seen as a method to solve these problems in education. Content management systems (i.e. Google Classroom, Canvas) and other technological innovations have assisted teachers in managing these issues, but as class sizes keep increasing and other problems worsen, teachers will require more assistance to manage the larger groups while providing the same quality of education (NAEP, 2023). Additionally, the impact that content management systems have on education quality is unknown, so teachers require other tools to better educate their students (Widiyatmoko, 2021). One such tool that has been developed in recent years is an educational robot, which teaches students skills and material like a teacher.

Reardon (2019) discusses the implementation of robots as teachers in education, specifically to special education. The field of special education has experienced teacher shortages more than the field of education as a whole, so technological innovations which help teachers address the needs of large class sizes are especially relevant (Sutcher, 2019). Examining how robots were implemented in special education, Reardon determined that "[robotic] instruction allowed the students to learn the skills to mastery." However, this method of teaching with educational robots has not only been successful in special education. In a meta-analysis of 17 articles regarding educational robots, Wang found evidence that "educational robots [had] a moderate but significantly positive effect on student learning outcomes" (Wang, 2023). Despite the apparent successes of educational robots assisting in student learning, they have seen limited implementation in school systems. There exists this divide, where the benefits of educational robots are apparent, yet the implementation of this solution is lacking.

In this paper, I will examine the role of robots in education and the factors that limit their implementation in education. This paper analyzes media surrounding educational robots, including scholarly journals, education reports, and articles to establish an understanding of the attitudes of actor groups within the educational system. Then, conflicts between these actor groups are identified to understand the potential reasons why educational robots are not implemented in schools.

Mitigating Problems with Education Robots:

With all of the problems with the current education system, how do we create a system that provides students with a better and more robust education to prepare them to contribute to society? One such method is to supplement traditional education with technological innovations, with one of those innovations being educational robots; meaning, have robots educate students about various subjects, such as math, reading, or life skills, to assist teachers in managing their class (NAEP, 2023). Studying the development of educational robots will enable greater understanding of the implementation of previous technological innovations in education.

Technological innovations in education have attempted to provide a solution to the problems that plague the current education system, such as absenteeism, students scoring worse on standardized examinations, and teacher burnout, but the effectiveness of these interventions is unknown (NAEP, 2023). For example, one such technological innovation in education are digital content management systems, like Google Classroom, Canvas, and Collab. Google Classroom was created in 2014, and since its creation has been used to help teachers and students organize assignments, quizzes, and readings. However, test scores since its implementation have continued to decrease. This can be seen in Figure 1, where since 2012 average test scores in reading and mathematics have decreased among 13 year olds from 2012 to 2020 (prior to the COVID-19 pandemic impacting education). With the goal to improve education, Google Classroom was developed and launched, but the actual impact that this specific technological innovation would have is unknown and potentially could have impeded the learning of students.

In traditional education settings, educational robots have been proven to be effective educators. There are a variety of ways that robots can and have been integrated in education, including, but not limited to, a tutor/tutee education style, life skills teaching, and large group instruction. A tutor/tutee education style is where the robot takes the role of the tutor, and the student the tutee.

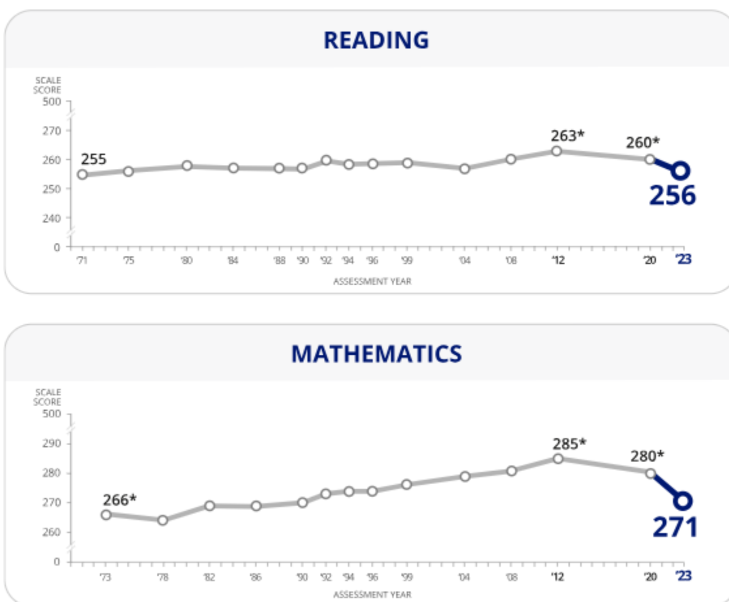

Figure 1: NAEP long-term reading and mathematics average scores of13-year-old students (retrieved from NAEP 2023)

Then, the robot instructs the student one on one about the subject, and the student learns the material; additionally, these roles may be switched and the student takes the role of the tutor and the robot takes the role of the tutee. In this case, the student takes control of the learning process, and it is shown that retention of this information is greater when the student assumes the role of the tutor as opposed to when the student is the tutee (Ekstrom, 2022). Additionally, educational robots have been utilized to teach many different topics, such as English, Chinese, Computer Science, and Mathematics (Wang, 2023). This provides a strong basis where robots can be used in education, as students have demonstrated their capability to learn from educational robots.

Robots can also be effective instructors in non-traditional educational settings. In this case, where the robot teaches the student some life skills, like counting change, the robot instructors saw greater success than conventional learning in imparting the skills to their students who had a learning disability (Reardon, 2019). Another case where robots have been proven effective in educating life skills to students is falling asleep in stressful environments (Bindsbergen, 2022). Students are able to not only learn information from robots, but also develop life skills under the instruction of a robot, demonstrating the effectiveness of robotic instruction in some cases.

The need for robotic educators comes from the problems with the current education system and the issues that are deepening as time progresses. The COVID-19 epidemic led to a massive increase in teacher retirements and resignations and the volume of new teachers are not able to keep up with that increased rate of retirement (Carver-Thomas, 2022). This requires the remaining teachers which continue to teach to pick up the slack that those teachers leave behind, with teachers still in the profession managing large classes with more limited resources and funding (Sutcher, 2019). Additionally, underqualified teachers are being hired at increasing rates as a direct result of the increase in resignations, so students are not the recipients of the same quality of education (Carver-Thomas, 2022). All of this results in students scoring lower on standardized tests, which has been an ongoing trend but has been exacerbated by the COVID-19 pandemic and the mass retiring of teachers (NAEP Reading Assessment 2022, NAEP Mathematics Assessment 2022). These are the problems that exist in the current education system, and educational robots may provide a solution to the problems present in the existing education system.

One way that robots can improve education is by increasing student engagement with the learning process. Effective education requires active participation from the students, and robots not only increase educational engagement, but the educational preferences of some students indicate that the robots lead the students to be more engaged in their learning (Zhang, 2021). In the current educational system, students are missing more days/month of school than before (NAEP, 2022). Increasing student engagement in learning will decrease the likelihood of truancy because students are more invested in learning with material which is more engaging. Additionally, some students indicated preferences for learning with a robot rather than a human teacher (Yueh, 2020). This leads to students being more engaged in education, and driving student success. Lastly, engagement in learning truly does drive student success (Arbaugh, 2000). While other factors may affect student learning, student engagement has been shown to drastically increase the effectiveness of instructional time, and increasing student engagement through robotic instruction may minimize truancy and some other problems that the education system faces.

Robots may provide a promising supplement to traditional learning, but does the implementation of robots in schools solve the problems embedded in the education system? To be an effective solution, robots must be deployed at scale to schools across the country. There must be research and development of the robots, manufacturing of the robots, development of curriculum using the robots in each school district, and finally teachers using the robots to instruct students. These processes all have an associated cost, and it is difficult to determine if the money is best spent developing this system or improving the current system in place. Increased allocation of resources to schools will provide better educational outcomes for students, ignoring the time required to develop robotic educational tools. While educational robots are being developed and tested, the quality of education that students receive will continue to deteriorate and students will score lower on these standardized tests. Additionally, selecting to develop educational robots will alarm current teachers, as they will worry about their jobs. This will have to be addressed if the robot system was to be developed. Additionally, once the robots have been developed, there should be technicians which maintain the robots, and this entire sector of jobs must be created prior to robots implementation. While robots provide a promising supplement to traditional schooling, it may be too costly when compared to other solutions the current system requires to become better.

Applying Discourse Analysis to Educational Robots:

The analytical approach that was used to analyze the evidence for this paper is discourse analysis (Neeley, 2008). As a research approach, discourse analysis focuses on language and communication as a way to understand social phenomena and occurrences, and attempts to use the language of discourse to uncover hidden meanings and underlying assumptions in society. This requires the examination and analysis of various forms of media, including, but not limited to, journal articles, newspaper articles, and government reports to derive the hidden meaning from the language used in that media.

Previous research has focused on qualitative studies of educational robots, focusing on the attitudes of various stakeholder groups (Smakman, 2021). Based on the research, five major attitudes to robots can be identified, with the attitudes being enthusiast, practical, troubled, skeptic, and mindfully positive. Enthusiasts refer to the group that show positive attitudes towards the use of robots in education, and the robots will provide great enrichment to students. The practical attitude has no strong views about the effectiveness of robots, but is concerned about the social development of children. The troubled group has extremely strong concerns regarding data privacy and sharing of information that is collected using the robot, and view the robot as a disruptor in the education system. Skeptics view that robots have no positive impact on schooling for children, and robots should actively be avoided in education. Lastly, the mindfully positive attitude shares similar attitudes with the enthusiast, yet are more concerned about data privacy and security. A survey was conducted, and attitudes held by specific stakeholders can be seen in Table 1. The identification of various stakeholders and the schema of certain attitudes towards robots as depicted in the five attitudes provided a basis for my analysis by situating these groups in conflict with one another, and using the conflict to identify the dominant discourses.

Socio-Demographic Characteristics		**Cluster (CL)**				
		Cl 1 Enthusiast	**Cl 2 Practical**	**Cl 3 Troubled**	**Cl 4 Sceptic**	**Cl 5 Mindfully Positive**
Stakeholder group	Parents with primary school children	**22%**	20%	*11%*	18%	20%
	Primary school teachers	*7%*	**28%**	14%	9%	*7%*
	School directors/management	10%	*3%*	**18%**	15%	14%
	Government policymakers/advisors	15%	*14%*	17%	**30%**	20%
	Employees of robotics industry	**20%**	6%	*5%*	6%	12%
	Students of education	14%	18%	**24%**	18%	*12%*
	Other	12%	11%	10%	*3%*	**16%**
Experience with robots	No	*67%*	**92%**	82%	88%	69%
	Yes	**33%**	*8%*	18%	13%	31%
Gender	Male	45%	36%	*34%*	48%	**51%**
	Female	55%	63%	**66%**	52%	*49%*
Income	Low (<€2.816 p/m)	*20%*	31%	24%	**35%**	22%
	Middle (€2.816–€5.632 p/m)	59%	55%	**66%**	57%	*52%*
	High (>€5.632 gross p/m)	18%	14%	10%	*9%*	**26%**
Highest finished education level	Secondary school	*9%*	**17%**	12%	13%	*9%*
	Vocational education (MBO)	11%	**18%**	*8%*	13%	9%
	University of Applied Sciences (HBO)	47%	43%	47%	**53%**	*39%*
	University of Science (WO)	32%	23%	32%	*22%*	**44%**

Table 1: Attitudes of groups regarding educational robots
(Retrieved from Smakman 2021)

The evidence analyzed in this study draws from technical studies of educational robots, STS studies on educational robots, and articles about educational robots. Additionally, a lot of the technical literature about educational robots focused on the implementation of educational robots in non-traditional classrooms, meaning either special needs classrooms or completely outside of a classroom setting. However, studies conducted in Eastern Europe and Eastern Asia focused on the more traditional classroom setting, with a teacher teaching multiple students or a one on one tutor/tutee setup. Despite the differences in implementation of educational robots between the United States and Eastern Europe and Asia, the inclusion of robots in education improved learning and educational outcomes (Wang 2023). There seems to be this disconnect, where the technical literature states that the inclusion of educational robots in student learning improves educational outcomes for students, yet the technological innovation of educational robots is not included in schools and other settings where that could really benefit from their implementation.The lack of educational robots in the education system despite their apparent benefits is where the analysis will be centered. Through analyzing technical studies of educational robots, STS studies on educational robots, and articles about educational robots, major discourses can be identified surrounding technological innovation and its implementation in the education system.

There is a specific set of steps that need to be followed when using discourse theory to provide a robust analysis of educational robots. The first step is to collect materials about the topic. In the case of educational robots, this refers to materials that discuss educational robots and the implementation of educational robots in education. The next step is to analyze and annotate the materials, looking for discourse patterns to identify some common discourses that may be present across all the material. Then, identify the groups that hold each specific attitude, and explore where the conflict in the discourse is strongest. A single point of contention between groups may cause multiple discourses, so only the strongest discourse which is that point of contention should be analyzed. Then, after the strongest discourses have been identified, the discourses identified within the context of educational robots can be applied to other technological innovations in education and conclusions are drawn. The procedure for this analysis can be seen summarized in Table 2.

Table 2: Steps in performing discourse analysis (Created by Author)

Step	Action in relation to educational robots
Collect Materials	Collect media and materials which about educational robots and their implementation in schools
Analyze and Annotate	Examine the materials in depth, looking for discourse patterns in the material
Identify Discourses	From the annotations and analysis, identify key discourses present in the materials. There will be a lot of disagreements, but only the strongest discourses should be considered
Investigate Discourses	Explore the strongest discourses, identifying the identities of the groups on each side of the discourse
Draw Conclusions	Summarize findings and discuss how educational robots function relate to similar technological innovations in education

Discourse theory provides a strong approach to analyze the actors in the field of educational robots (van Leeuwen 2008). The research approach of discourse analysis was first created in the mid 1980's, but would develop throughout the 1990's and early 2000's to a more developed research method. Discourse analysis provides a robust method to analyze inter-group and intra-group conflict while still centering the conflict within the context of society. Discourse analysis provided a strong basis for my analysis of educational robots because when any technological innovation occurs, there are proponents and opponents of that innovation. Discourse theory provides an approach to contextualize the conflict present in various forms of media about a topic, in this case educational robots.

Dominant Discourses and Results:

This section discusses the results of the discourse analysis, which focuses on the research and implementation of robots in educational systems in various countries. The majority of the resources analyzed come from academic journals and government reports regarding education quality.

All of the discourses positioned the groups identified by Smakman in opposition to one another. For example, the enthusiast and skeptic groups have fundamentally different views on the implementation of robots in education, with the enthusiast group supporting the implementation of robots in education while skeptics are against the implementation. These groups would be on opposing sides of the discourse of uncertainty and skepticism, creating controversy and promoting discourse.

The most prominent discourse discovered relates to the topic of technological solutions in education. This discourse frames educational robots as the solution to the problems that face the current educational system, emphasizing the potential that robots may have to enhance education, either by increasing student engagement or providing individualized instruction time to students. Much of the literature examined focused on the outright successes or failures of the robotic instructors, rather than considering the root causes of the current problems in the education system. The use of technology to address these issues present in the education system only. The discussion of this discourse is prevalent in all media analyzed for this paper, where it is often assumed that robots will improve educational outcomes of students.

Another discourse present in the material analyzed was the role of the robot in the classroom. Almost all of the studies placed the robot in a different place in relation to the teacher, students, and curriculum. Some studies completely replaced the teacher as an instructor, while other literature placed studies as a tool which teachers can use to improve education. The exact role of robots in education fails to fulfill a specific role, rather the robots fill whatever role they are expected to perform based on the people conducting the study. In this case, either the collaborative relationship between robots and teachers bettering the education of their students or the antagonistic relationship between teachers and robots in competition for the same jobs.

Lastly, the two discourses of ethical and societal concerns and the skepticism of the implementation of education robots are a discourse present in much of the media analyzed. These concerns drew from the concern of how education changes when robots are included in the process of education. A summary of the dominant discourses identified can be found in Table 3.

Table 3: Dominant Discourses found when analyzing literature (Created by Author)

Dominant Discourses on Educational Robots	Explanation
Technological Solution for Education	Often, technology is utilized as a solution to the problems of educators and the education system, but this fails to solve the root problems with the education system and leaves those problems unaddressed.
Role of Robot in Education	The role of the robot in teaching students is very flexible. The role can range from a collaborative relationship with a teacher to an antagonistic role with the robot independently instructing students, completely replacing the teacher.
Ethical and Societal Concerns	Education has always been a very human interaction between students and a teacher. Education will change with the implementation of robotic instructors, so shaping that change is
Uncertainty and Skepticism	The way that robots will impact education is unknown, and people can either embrace that change or deny its actualization

After discovering the discourses, the identification of actors within the educational system provides a basis for the discourse to be contextualized. The most relevant actors in this analysis are educators, students, technology companies, and policymakers. Students were centered in all the discourses identified, with many of the concerns surrounding educational robots centered around how students would be affected by the innovation. As can be seen with previous technological innovations whose goal is to improve education for students, the actual results can be varied. Educators and policymakers take similar roles in this analysis, where they drive the change for the inclusion of educational robots. Policymakers would create policy about the inclusion of technological robots in school curriculum and standards, and then educators would create lessons including educational robots to satisfy those requirements. Then, technology companies would be contracted out to create these robots, with the goal of maximizing profits. All of these actors are present in the implementation of educational robots in education and would shape the actual implementation of educational robots in schools, and each group will have their own stance on the previously mentioned discourses.

The dominant discourses and actors identified when performing this analysis on educational robots are present in any technological innovation, and underlying discourses when analyzing educational robots can be applied to other technological innovations in the field of education. Content management systems, such as Canvas, Google Classroom, and Collab, were integrated into teaching and learning in hopes to provide similar goals as educational robots, improving educational outcomes for students, but to varying degrees of success. These tools only work well when there are no problems, but if problems are created then the tool actually impedes students' learning. Canvas, and other content management systems for education, fade into the background when there are no problems with using the software, but as soon as a problem with the system is created the system becomes an impediment to learning. Thus, an innovation with the goal to organize student learning actually impedes it. This draws back to the dominant discourse of 'Technological Solution for Education' identified in the analysis of educational robots. as the problems of education are attempted to be solved with technology. This does not mean that technology innovations in education always impede student learning, but there are trade offs that occur when some sort of technological innovation is implemented.

Conclusion:

Innovations in educational technology will always occur, and it is up to stakeholders to determine the best way that the innovation should be implemented in schools, or even if the innovation should be implemented at all. Discourse analysis of the material allows for various points of views to be considered in determining the fate of the technological innovation. Educational robots provide an interesting case study to analyze technological innovation in education, where many of the discourses and actors present in this analysis are related to other technological innovations. Of the findings, the most significant result is the dominant discourse of technological solutions to problems in education, where technology is seen as some sort of "great equalizer" that will solve all problems in education. In reality, the education system is formed of a complex set of stakeholders, and the attitudes of these stakeholders is what actually affects the implementation of robotics in education. Additionally, there exists a lot of skepticism regarding robotic educators as teaching is seen as a very human interaction between students and teachers, so there is growing concern for robotic instructors in school.

Discourse theory provides a strong foundation for the analysis conducted in this paper, but it still has some limitations. Discourse analysis groups individuals into stakeholder groups, so the agency of individuals intentionally removed; also, discourse analysis focuses on media, and does not give light to under-represented groups. A lot of the sources analyzed focused on student learning and success, but did not report the actual attitudes of students on educational robots, focusing on teachers, parents, and school administrators. However, this limits the analysis of students and other stakeholders who are not represented in such media. Including more writing directly from students can help alleviate some of the problems associated with this deficiency.

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