The slow and cautious integration of LLMs into the education system

A Research Paper submitted to the Department of Engineering and Society

Presented to the Faculty of the School of Engineering and Applied Science University of Virginia • Charlottesville, Virginia

In Partial Fulfillment of the Requirements for the Degree Bachelor of Science, School of Engineering

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Spring, 2024

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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1. Introduction: The Rise of Large Language Models in Education:

A Large Language Model (LLM) refers to a type of artificial intelligence model that is designed to understand, generate, and interact with human language at a large scale. As of late, LLMs have significantly increased in popularity. LLMs such as ChatGPT and Bard, have been hot topics not only in the machine learning field but also in outlets such as social media, news, and education. These tools have incredible capabilities from text/image generation, analysis, and amazing human interaction. These tools are only becoming more powerful with ChatGPT 4 releasing less than a year after ChatGPT 3 was released to the public. Due to this rapid development and growth, these LLM technologies are starting to leak into more areas including fields such as finance, guidance, self-service, and software engineering (Clair 2024). For this paper the focus is on the introduction of LLMs into the educational system. Specifically, how schools are trying to implement LLMs into their systems using the current resources and tools available. My research question is "How are schools currently using LLMs in teaching and what kind of experiments are they running?" ANT (Actor Network Theory) is utilized in order to analyze what kind of relationships must be altered and changed in this process. As seen from early testing of ChatGPT in the classroom, models successfully assessed performance in novice python courses yielding around 95% correct responses (Kiesler 2023). As a result, it is fair that there is definitely already success in the education field, however this paper explores that further and examines how LLMs are being used in specific education systems around the world. Having touched on the surge in popularity and application of LLMs, particularly in educational contexts,

this paper will now explore the different methodologies used to examine how schools are currently utilizing these technologies and the experiments they are conducting.

2. Methodological Approachs for Investigating LLMs in Educational Settings

How are schools currently using LLMs in teaching and what kind of experiments are they running?

The research for this paper was conducted with a few key goals in mind: identifying the steps teachers are taking to enhance teaching with LLMs, understanding the results they have garnered, and discovering their plans. For this work, the main methods used are document analysis and case studies. Academic articles and integration results/reports are able to provide experimental data and insight into what kinds of experiments and steps educators are taking. Discourse analysis is also present in the research performed for this paper. Media sources such as press releases and news media are non-traditional forms of documents currently heavily covering AI topics, so they are worth looking into. The main keywords being used when I am searching for documents are “LLMs”, “Education”, “Generative AI”, and “Artificial Intelligence.”

3. Background: The Evolution and Impact of AI Technologies in Education

Delving into this research paper, it is important that context is set up for the current state of AI. Currently, the integration of LLMs is in an adaptive phase. The shift to this new LLM technology requires extensive experimentation, given its unprecedented nature. It is imperative that this technology is utilized to help humans grow rather than forming complete reliance on it. This shift is like the ongoing integration of robots, where humans continue to maximize benefits

while mitigating impacts on quality of life, (Baber 2020) and also similar to the shift to the use of calculators in schools. Like these two past events, LLMs will bring some form of mutual shaping to their sociotechnical system, in our case the education system. To look at some of the potential benefits LLMs have, this paper looks into existing research that's being conducted and current ideas educators have moving forward. Educators are already thinking of innovative ways to utilize LLMs, such as providing alternative explanations for complex concepts, creating additional examples and practice questions, and assisting in the structuring of courses (Joshi et al.). Additionally, models can assist with administrative tasks, including grading and performance evaluation, helping not only teachers receive a relief on workload, but also allow students to have on demand feedback for work (Manhiça 2023). LLMs also possess the ability to learn from user data, making them adaptable tools capable of catering to the individual needs of students (Gifford 2023). First and foremost, while AI is growing rapidly, there are a mountain of obstacles that come with the field. Educators will have to find LLM models that are appropriate for school environments. There are certain models that are very good at X but poor at Y. So finding the correct model that minimizes the tradeoffs and strikes a good balance is a piece of the puzzle. Obstacles such as data privacy are also a big concern. While it would be ideal if schools could own and run the models on their own servers, this is not practical and is incredibly expensive meaning schools will have to outsource and use the models from somewhere else (Falconer 2023). The problem arises when sensitive school records and data need to be used but schools risk leaking them to these big corporations that own and host these large LLMs. Another very common obstacle is over reliance on these LLMs and students not learning how to think

critically for themselves. While it is important to look forward to the benefits LLMs may bring, educators need to also keep in mind the many struggles they will have to face.

4. STS Framework: Applying Actor Network Theory to LLM Integration in Education

For my research paper, the ANT framework will be utilized for analysis. I will be looking into the system of education and how the introduction of LLMs will essentially help transform and change that existing system. I want to analyze the change in the role of professors as an actor in the system and how it will change with the implementation of LLMs. LLMs could either greatly reduce or increase the role of professors in the system. In addition new actors would most likely be introduced to the system as a result of LLMs being implemented. Although there are many significant actors involved, I want to give some focus to smaller groups that will have a crucial role in facilitating LLM functionality. Model designers will be responsible for creating different models depending on a school's needs. LLMs are typically trained on "training data" that helps them learn and recognize patterns. If the LLM's training data is not sufficient and broad, educators may encounter problems. Models that perform well with training data can perform poorly with actual human data, especially when exposed to unconventional or grammatically incorrect writing, presenting limitations that need to be addressed for school use (Michael 2023). Actually finding a source of these LLMs that is affordable and practical will be a big obstacle that comes with my research topic. Actors such as IT Teams and school budgeting teams will also have to start playing a bigger role if LLM integration moves forward. There has been similar research with ANT in the LLM field with concerns of biases and understanding in

LLMs (Morton 2023). The article goes into surrounding concerns about the worry that comes with putting in so much trust into AI when there are many potential problems that can occur when trying to use and adapt to LLMs. I want to look at this system, but on a smaller scale in the education sociotechnical system. My research will be similar to that of the authors but I will look at the system on a smaller scale, focusing on the surrounding effects on the ANT of just the school system.

5. Results and Discussion: How Schools Are Implementing and Benefiting from LLMs

Schools are using LLMs to provide more personalization for each student, improve learning environments, and give students more access to resources. While LLMs are still in their early stages of school integration, there are currently many schools and companies implementing new found LLM technology into their institutions. Educational institutions are increasingly integrating tools like ChatGPT into their systems to explore and evaluate their potential benefits. New startups and companies are also forming in order to start creating custom LLM tools for the use of education. These tools are being developed and slowly integrated into schools around the world with the intention of revolutionizing how education is delivered. The goal with these technologies is to let teachers perform teaching techniques that could not be done by an individual teacher alone such as different learning styles for each student, different pace of learning for each student and even breaking down barriers such as socioeconomic status by giving students access to these high complexity LLMs that have been trained on millions of resources and data. One of the main trends seen in existing research is that teachers are being careful to make sure that LLMs are acting solely as a supplementary source rather than a

replacement. Making sure that these LLMs have a balance while not overshadowing the role of the teacher is a goal that educators are making sure to practice as they slowly integrate these technologies in. While the current integration of LLMs shows promise, the schools and educators are also trying to deal with many ethical considerations while developing and integrating LLM technology such as data privacy, AI biases, and misinformation.

5.1 Challenges and Ethical Considerations in the Use of LLMs in Schools

Before getting into the main results of this paper, it is important to first address the restrictions and ethical issues that these schools/educators must consider when implementing these LLMs into our classrooms. One author states that primary issues to consider are AI biases and misinformation, these are factual errors that are generated by the AI (Mathieson, 2023). Educators must make sure that when they set up and develop these complex LLMs they must be prepared to handle inaccuracies generated by the LLM. Another significant risk is perfectly handling the balance between LLM and teacher to student interaction. Academic integrity is going to be a clear issue with the introduction of these LLMs. Ko argues that LLMs are limited to the data they are trained, meaning that if students learn from LLMs they are having a superficial form of learning that is derived from critical thinking and problem solving (Ko 2024). As a result educators will have to make sure to be careful with how they approach LLM integration. They will have to ensure a proper balance in reaping the max benefits from LLMs while also making sure to nurture and guide their students to think critically. Similar to tools

such as calculators, spell checks, and electronics teachers will have to learn how to use these LLMs as supplementary tools rather than replacements.

Another significant issue that is present in many different fields including education is the issue of data privacy. A problem with LLMs is that every single thing that you type into the LLM will be remembered and used to train the model in order to improve or update it. In addition it is not exactly easy to unlearn or delete knowledge data from an LLM. Therefore schools and educators will have to ensure that sensitive data such as school records and student information are handled in compliance with FERPA regulations, protecting the privacy of students and making sure that none of this information is leaked out to the big companies that will be hosting the LLMs.

While LLMs show great promise it is still important to remember there are many restrictions and ethical issues left to consider before as educators move forward with continued LLM integration into schools. Pilot programs and collaborative research efforts are being initiated to explore the effective use of LLMs for personalized learning, cognitive support, and enhancing student engagement.

5.2 Actor Network Theory Insights: The Changing Roles in Education Due to LLMs

The initial challenges schools are addressing concern the integration of these tools into their current systems. The education system is viewed as a network of actors, right now the groups are mainly consistent students, faculty, teachers, and a few more minor groups such as

parents. The first step that educators are trying to tackle is to find out where LLMs will fit into this network. Finding out where LLMs will fit is the first part of the challenge and in this paragraph we will discuss results on how schools are handling this first step. Schools are currently navigating a complex landscape of actors, including students, faculty, teachers, and parents. The approach to incorporating LLMs involves a strategy, focusing on making LLMs supplementary rather than replacing teachers and professors. Educators are actively working with stakeholders to understand and align LLM capabilities with educational goals, emphasizing the augmentation of teaching rather than the replacement of it. According to Schiff, pilot programs and collaborative research efforts are being set up to analyze the effective use of LLMs for personalized learning, and enhancing student engagement (Schiff 2021). AIEd (Artificial Intelligence in Education) are specific AI technologies that are currently being experimented and tested by researchers. These tools are used right now mainly for real time feedback and are meant to try and provide individualization that a single teacher cannot provide. According to Schiff, these AIEd tools are being integrated all over the world with technologies already appearing in some schools in the United States, China, India, and Europe (Schiff 2021). As schools work on the integration of LLMs and AIEd into existing educational systems, collaborative efforts and pilot programs are focusing on a way for a supplementary approach that enhances teaching and learning experiences while respecting the roles of educators and stakeholders alike. Using ANT, the relationships among educators, students, technology providers, and policymakers can be analyzed as LLMs are introduced into the educational environment. ANT helps us understand how each actor influences and is influenced by others in the network, showing how the roles and

expectations of traditional and new stakeholders are redefined as a result of this groundbreaking technology

LLMs in schools are still relatively new, as a result, experimentation and fine tuning are still a key focus. Educators and education companies are constantly experimenting and trying to maximize the potential for LLMs such as ChatGPT4 and Codex in schools. As Denny states, educators are constantly performing rigorous evaluations of LLM capabilities and how they would perform in school environments in order to ensure good performance (Denny et al 2024). Models such as Codex, an LLM tool developed by OpenAI designed to generate human text and code, has been tested with real test questions from programming classes in order to see if it is up to par to "tutor" or "teach" students. The results have been promising as the Codex LLM is able to perform in the top quartile of students (Denny et al 2024). However the use of LLMs goes beyond simply just solving problems. Educators have been testing its proficiency in generating unique problems from scratch, problem explanations, and improving error messages for students. Moreover, Denny also argues that the inclusion of LLMs will help students think more critically as they most cleverly generate prompts in order to communicate and get the desired output from LLMs (Denny et al 2024). It can be seen, LLMs have great implications for the future of education, improving many different aspects of education such as problem generation, problem explanation, and student personalization. In order to help these LLMs reach their potential, educators are constantly experimenting and tuning LLMs for the classroom.

For the next study, educators were able to be more hands on with LLM technology in the classroom. Jeon discusses an experiment in South Korea in which eleven language teachers were given access to ChatGPT. The teachers were told to integrate ChatGPT into their teaching activities for the next two weeks and told to report back their results and findings during post-use interviews (Jeon 2023). Jeon discusses that the researchers identified the 4 different roles ChatGPT served during the two-week period: the interlocutor, content provider, teaching assistant, and evaluator. These roles were very effective according to the experiment, engaging students in conversation, generating and customizing educational materials, assisting with grammar and vocabulary, and aiding in student evaluation. As you can see, ChatGPT was utilized in many different ways, such as role-plays and interactive language games, offering a more dynamic and interactive learning experience. Teachers utilized the AI to produce learning materials as well, including dialogue scripts and short stories, tailored to students' specific needs and levels, demonstrating its ability to personalize education. While it is clear that ChatGPT was able to bring great value to the classroom, the teachers interviewed made one thing very clear.

Similar to past cases looked at in this paper, they all emphasize the point of using LLMs to complement but not replace traditional teaching methods. Yet again, here is that theme of ensuring that LLMs enhance but do not replace teachers in the existing social network that is the classroom. In our network of actors, teachers are hoping to potentially have LLMs as a completely new actor or as a complementary actor rather than a replacement in the network. One of the main ideas here is the actors of LLMs and teachers influencing and affecting each other.

On one hand the LLMs in the future are going to make the lives of teachers easier, helping them generate learning materials. On the other hand, how the teachers decide to implement the LLMs will influence the role of the LLM actor in the network not only now but in the future. This also has implications for the established networks as the integration of LLMs into this network will most likely alter the role of teachers giving them more tools to work with, therefore more capabilities.

LLMs such as ChatGPT, Bard, and the earlier mentioned Codex are already great tools that are clearly delivering great results. However, another big component of integration of LLMs is focusing on tuning and customizing LLMs in order to be education specific. For the next case, Park et al. (2024) introduces a personalized tutoring system that uses LLMs to enhance learning through conversation-based interactions, focusing on English writing concepts from the SAT Writing test. The system learns strategies and adapts from student assessments, employing LLMs for dynamic, personalized tutoring. The model was focused on emphasizing personalization in student modeling, which includes making the model focusing on learning style and proficiency levels, taking advantage of GPT-4's capabilities and building on top of it (Park et al 2024). The system was tested with 20 participants, demonstrating its ability to personalize tutoring based on individual student assessments. The system was successful in adjusting teaching methods according to a student’s thinking method and learning styles. This is good progress and a step in the right direction. However, challenges did occur throughout the process and there were problems ensuring that the system was always successful in adapting the students' learning

methods. The study states that more research is needed to improve the system's personalization strategies and adaptability. There are implications for the actor network discussed in this article. As LLMs become more dependent on the student for their integration and personalization, the student's role in the network becomes larger in how they are taught. Since a student's interactions with the LLMs shape how the systems are integrated and developed, the student's network role in their own learning will be amplified and the role of LLMs in the network will become more dependent on the student.

5.3 Future Work: Enhancing Personalization and Ethical Standards in LLM Applications

In terms of future work for this field, there are several tasks that researchers and educators hope to accomplish before ChatGPT starts being mass implemented all around the world. AI researcher O'Leary Improving personalization and adaptability of these LLMs is currently an ongoing effort. Ideally getting these LLMs to match both an individual's learning style and their emotional style would enhance engagement and effectiveness of these LLMs (O'Leary 2023)."Researchers also hope to enhance the global accessibility of LLMs, including for disabled learners. Accessibility also comes with ease of integration, so researchers are looking for the best way to make LLM educational technology simple to integrate into schools, hoping for multi-platform support, easy installation, and more. (O'Leary 2023) Like stated at the start of this section, prioritizing ethical AI is a main concern too, making sure that the data does not get into the wrong hands and trying to minimize the misinformation spread by the AI. This means creating policies to safeguard student data, strategies and model tuning to prevent

potential misinformation spread by AI, and standards to ensure the responsible use of LLMs. As O'Leary (2023) points out, prioritizing ethical AI practices is not only to protect users but also to maintain trust in the transformative potential of these technologies for educational advancement (O'Leary 2023).

6. Conclusion: Reflecting on the Cautious Integration of LLMs into Educational Practices

In conclusion, schools are taking many cautious steps in order to start integrating LLMs into the education system. These steps include running experiments in classrooms involving LLMs, testing LLMs in various different fields (examinations, question generation, material review), and developing/manipulating LLMs in various different ways to optimize them for the education environment. While LLMs are being developed and integrated into schools, educators are constantly trying to ensure that these tools complement rather than replace teachers. The significance of this research question is important as these LLMs will have a major role in the future of education. The studies and cases reviewed in this paper not only show the diverse ways in which LLMs are being piloted across educational settings but also shed light on the potential and pitfalls of these technologies. The insights drawn from the experiments and case studies highlight a critical shift towards a more careful, responsible, and innovative approach to integrating AI in education. These findings suggest that the future of education with LLMs depends not just on technological advancements but on a strategy that prioritizes ethical considerations, personalization, and the augmentation of human teaching capabilities, rather than the replacement of it. The promise of LLMs extends beyond simply making academics "easier"

similar to tools such as spell check or the calculator. The experiments and research papers studied in this paper offer a sneak peek into a future where education is more accessible, personalized, and equitable.

Works Cited

Denny, P., Prather, J., Becker, B. A., Finnie-Ansley, J., Hellas, A., Leinonen, J., Luxton-Reilly, A., Reeves, B. N., Santos, E. A., & Sarsa, S. (2024). Computing Education in the Era of Generative AI. Communications of the ACM, 67(2), 56–67. https://doi.org/10.1145/3624720

Falconer, S. (2023, October 23). *Privacy in the age of Generative AI*. Stack Overflow. https://stackoverflow.blog/2023/10/23/privacy-in-the-age-of-generative-ai/

Jeon, J., Lee, S. Large language models in education: A focus on the complementary relationship between human teachers and ChatGPT. Educ Inf Technol 28, 15873–15892 (2023). https://doi.org/10.1007/s10639-023-11834-1

Ko, A. J. (2024, January 8). More than calculators: Why large language models threaten public education. Medium. https://medium.com/bits-and-behavior/more-than-calculators-why-large-language-models-threaten-public-education-480dd5300939

Mathieson, S. (2023, July 31). *Large language models harnessed for education: Computer Weekly*. ComputerWeekly.com.

https://www.computerweekly.com/feature/Large-language-models-harnessed-for-educatio n

O'Leary, G. (2024, February 12). *The Future of Education: LLMS in personalized learning and development*. LinkedIn. https://www.linkedin.com/pulse/future-education-llms-personalized-learning-gavin-o-lear y-p90ve

Park, M., Kim, S., Lee, S., Kwon, S., & Kim, K. (2024, March 21). *Empowering personalized learning through a conversation-based tutoring system with student modeling*. arXiv.org. https://arxiv.org/abs/2403.14071v1

Schiff D. (2021). Out of the laboratory and into the classroom: the future of artificial intelligence in education. *AI & society*, *36*(1), 331–348. https://doi.org/10.1007/s00146-020-01033-8

Baber, T. (2020). 2020 ASME Human-Powered Vehicle Competition University of Virginia 5 Orange Team; Robots and Society: Robots Influence on Manufacturing. [Bachelor of Science, University of Virginia, School of Engineering and Applied Science]. University of Virginia. https://doi.org/10.18130/v3-6300-2n19

Falconer, S. (2023, October 23). Privacy in the Age of Generative AI - Stack Overflow. Stackoverflow.blog. https://stackoverflow.blog/2023/10/23/privacy-in-the-ageof-generative-ai/

Gifford, A. (2023, October 11). Generative AI hits education, ushering in a sea change for Schools. GovTech. https://www.govtech.com/cde/generative-ai-hits-education-usheringin-a-sea-change-for-schools

Joshi, I., Budhiraja, R., Pranav, D. T., Jain, L., Deshpande, M., Srivastava, A., Rallapalli, S., Akolekar, H. D., Challa, J. S., & Kumar, D. (2023). "With Great Power Comes Great Responsibility!": Student and Instructor Perspectives on the influence of LLMs on Undergraduate Engineering Education. Cornell University Library, arXiv.org. https://arxiv.org/abs/2309.10694

Kiesler, N., & Schiffner, D. (2023, August 15). Large Language Models in Introductory Programming Education: ChatGPT's Performance and Implications for Assessments. ArXiv.org. https://arxiv.org/abs/2308.08572

Le Clair, C. (2024). Six Ways to Use Llms Operationally in the Enterprise. Computer Weekly, 16–19. 6

Manhiça, R., Santos, A., & Cravino, J. (2022). The use of artificial intelligence in learning management systems in the context of higher education: Systematic literature review. CISTI (Iberian Conference on Information Systems & Technologies / Conferência Ibérica de Sistemas e Tecnologias de Informação) Proceedings, 17. 10.23919/CISTI54924.2022.9820205

Michael, S. O., Karnalim, O., Carlos, A. S., & Liut, M. (2023). Detecting LLM-Generated Text in Computing Education: A Comparative Study for ChatGPT Cases. Cornell University Library, arXiv.org. https://arxiv.org/abs/2307.07411

Morton, J. L. (2023, September 8). How Actor Network Theory explains ChatGPT and the new power relationships in the age of AI - The Academic. Theacademic.com. https://theacademic.com/actor-network-theory-explains-chatgpt-and-ai/