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Survey on Generative AI in Education

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ABSTRACT—This paper explores how large language models are being used in educational institutions, after which it goes on to examine their applications, challenges, and ethical implications. By synthesizing recent insights, the paper will delve into LLM text clustering, customization of higher education, and personalized learning. The presence of generative AI tools, such as ChatGPT, will transform the arena of research efficiency and adaptive learning. However, issues related to privacy, data security, and ethics such as algorithmic bias are still present and have to be sorted out. The paper presents suggestions for the responsible integration of LLMs into learning structures to nullify risk issues that may pose a threat to augmenting positive learning outcomes.
Index terms - Academic Resources, Generative AI, Student Support, Lecture Notes, Learning Enhancement.

I. INTRODUCTION

LLMssuchasGPT4andChatgptarechanging the way we think about education. These are powerful models that takes and generates human readable texts, opening doors for students teachers and researchers to get a lot done from automating routine tasks to creating more personalized learning experiences. LLMs are changing classrooms and making education more accessible, efficient and engaging. This paper explores the many ways LLMs are being used in education today. The challenges that go along with its use and what in the future is likely to be for it in academic settings.

A. Why LLMs Matter in Education

LLMs are now playing a significant role in the world of education, and there is a good reason for this. These models can understand and generate language in ways that make them useful across a wide range of tasks. Whether it is answering student questions, grading as-signments, or helping with research, LLMs are making life easier for both students and educators.

One of the biggest advantages offered by LLMs is that they can process large sums of information quickly and accurately. So, these are especially helpful when doing personalized learning instruction, allowing students to obtain a personal sense of feedback. For example, an LLM might explain a math concept in a way that makes sense to a struggling student while providing another student with more challenging work. Such individual- ized support is not something that traditional teaching methods can easily provide on a large scale.

With more schools and universities shifting towards digital and distant learning, LLMs also make education more fluid and accessible. They enable access to learning materials at any moment in time, from anyplace, and in a manner that best suits personal learning tastes. This is especially imperative given the evolving nature of education. Modern society has been shaped through rapid technological advancement in just about every area of living.

B. Real-World Applications of LLMs in Education

LLMs are already making a big impact in classrooms, research labs, and beyond. One exciting example is how they're being used to improve the way we classify and understand large sets of text. For instance, instead of relying on traditional algorithms to cluster related pieces of text together, LLMs can categorize documents based on specific criteria, like intent or topic. This is particularly useful for tasks like grading essays, sorting through academic papers, or helping students find the information they need.

Another area where LLMs are making a difference is in research. Tools like the AI-Based Research Companion (ARC) use LLMs for assisting students and researchers by suggesting appropriate sources, helping with data analysis, and even guiding the writing process. This would save hours of work, especially in fields like engineering

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or medicine, where the research process can be both data-heavy and time-consuming. Similarly, AI- powered chatbots like ”Digital Professor” are automating routine academic tasks, from grading quizzes to answering student inquiries, freeing up educators to focus on more meaningful aspects of teaching.

Personalized learning is another area where LLMs are shining. Techniques like Retrieval Augmented Generation (RAG) are enhancing how students interact with course materials. RAG allows LLMs to pull in relevant information from external sources, providing students with more accurate and context-specific answers to their questions. So, instead of just getting a generic response, students are receiving insights that are directly tied to their curriculum, making learning more engaging and effective.

C. Challenges and Ethical Questions

While the scope of LLMs in education is clear, their use also raises some important challenges. One of the biggest concerns is the issue of bias. Because LLMs learn from large datasets that may contain biased or incomplete information, they can sometimes reinforce harmful stereotypes or provide inaccurate answers. This is especially troubling in education, where fairness and equity are so important. If not carefully monitored, LLMs could end up giving certain students an unfair advantage or misrepresenting important information.

Another challenge is the risk of students becoming too reliant on AI-generated content. While LLMs can be great tools for learning, there’s a concern that students might use them to complete assignments without fully engaging with the material themselves. This could lead to a decline in critical thinking and creativity, as students might be tempted to take shortcuts rather than grappling with complex problems on their own.

Privacy is another important issue. Since LLMs process large amounts of data, including personal and sensitive information, it’s crucial that schools and universities have strong data protection policies in place. If not handled properly, student data could be at risk of being accessed or misused. Additionally, running these large models requires significant computing power, which can be a barrier for schools with limited resources. This raises questions about the environmental impact of LLMs, as the energy required to train and operate these models is substantial.

D. Looking Ahead: The Future of LLMs in Education

But despite all of these challenges, the future for LLMs in education does not seem in the least dire. Some truly very promising work involves utilizing transfer learning, in which adaptation to a novel task would be possible only with minimal need for retraining. It would thus be very specialized for educational establishments and fine-tuned either to subjects or areas of interest, so that they could prove highly useful both for students and teachers.

In the near future, we will more and more witness LLMs applied to personalized learning. Models are adaptive with real-time progression of the student, and the recommendations adjust according to this. One can imagine an LLM not only helping students with homework but also providing topics of interest or areas of strength for the student to learn. It would then make studying much more dynamic and interactive because it encourages students to go deeper into their studies.

While educational institutions need to be very careful with the use of LLMs, the technology is full of promise and should support but not replace the traditional method of teaching. Teachers will need to find a balance in the future between exercising the potential of AI and still retaining the humanness of learning through such skills as critical thinking, creativity, and social skills.

LLMs are changing the face of education. They have opened new ways of learning, teaching, and researching. The benefits can be very significant. While challenges persistinethics, privacy, and access, we can make learning environments more inclusive, efficient, and engaging for students of all backgrounds and abilities. By carefully integrating LLMs into the educational process, the future of education powered by AI is just beginning, and it promises exciting possibilities for everyone.

II. LITERATURE REVIEW

[1] Zhang et al. (2024) introduce a novel two-stage approach using large language models (LLMs) that turns text clustering into a classification-based problem. The system first generates potential labels for the dataset and then classifies texts into these labels, rather than relying on conventional clustering algorithms. This method ad- dresses a major challenge of traditional systems that use embeddings like BERT, as it does not require complex fine-tuning and hyper parameter adjustments.

The approach significantly improves

clustering accuracy, particularly in complex data sets involving tasks like intent detection and topic mining. Zhangetal. emphasize that few-shot learning enhances the model's performance and facilitates effective in-context learning. Despite the computational cost associated with an API-based implementation, the model effectively handles complex data distributions and yields better results than conventional methods. Overall, this method simplifies text clustering while increasing efficiency and accuracy, representing a significant breakthrough in the field.

[2] Kortemeyer offers a comprehensive overview of strategies for adapting Large Language Models (LLMs) for applications in higher education. The author identifies three primary methods: training models from scratch, fine-tuning preexisting models, and employing augmentation techniques such as Retrieval Augmented Generation(RAG).Training models from the ground up is noted to be overly complex and costly for most institutions, necessitating vast computational power and meticulously curated datasets. In contrast, fine-tuning pre-trainedopen-weightmodelslikeLlama3emergesas a more viable option, though it still requires considerable effort and a careful approach to maintain the model's overall performance.

The paper positions RAG as potentially the most practical method for numerous higher education scenarios. This technique enhances a standard LLM with relevant reference materials at the time of query, enabling customization without altering the foundational model. Kortemeyer discusses a RAG implementation at ETH Zurich, where course-specific chatbots are developed by embedding course materials and utilizing semantic search to retrieve pertinent information. This method is recognized for its relatively straightforward implementation and adaptability, as it can be applied to various commercial LLMs and easily updated or reconfigured.

A significant point emphasized throughout the pa-per is the necessity for robust inference infrastructure. Although cloud-based inference options are available for commercial models, they raise privacy issues and entail ongoing expenses. Institutions aiming to deploy custom models—whether developed from scratch or fine- tuned—encounter challenges in securing the required GPU resources for continuous inference. Kortemeyer ob-serves that most university supercomputing facilities are not optimally equipped for such an always-on service. The paper concludes by highlighting that there is no universal solution for customizing chatbots in higher education, with the optimal choice contingent upon factors such as available resources, privacy concerns, and the specific application at hand.

[3] Analysis of the general diffusion of generative LLMs like ChatGPT in different fields and their possible applications in the future, when using a data-driven approach, it relies on more than 3.8 million tweets between November2022andMay2023tocontextualize the tasks assigned by users to ChatGPT. The method incorporates several crucial steps in the process of data processing.

Using a rule-based NER system from NLP, the authors downloaded user-described tasks from their collection of tweets. The system extracted 31,747 unique tasks from this data, cleaning it for noise, text normalization, and grouping similar tasks. Using the BERT opic algorithm, which is a topic modeling tool based on NLP techniques to disclose patterns in big text datasets, they then clustered semantically similar tasks. That allowed them to realize six underlying business areas influenced by ChatGPT - namely human resources, programming, social media, office automation, search engines, and education.

The results demonstrate the usability of LLMs such as ChatGPT: it can be a coding assistant, a writing tool, or simply content creator. These features would actually cause vast changes in business because of the automation of most time-consuming tasks, from code generation and question answering to email composition and much more, resulting in a significantly increased efficiency of all industries. Finally, the authors connect the dots and provoke further research with respect to the integration of LLMs into innovation processes such as idea generation, selection, development, and market adoption. They also argue that such technologies should consider their social and ethical implications, a factor that is enhanced since they are likely to challenge and undermine traditional business models and operations.

[4] AI-Based Research Companion (ARC) is a plat- form developed to address challenges in undergraduate research by leveraging GPT-4. The platform aims to enhance student engagement in research through personalized recommendations, helping bridge the gap between academic theory and practical research.ARC serves as a solution by organizing and enhancing research activities using generative AI technology. Through ARC, students can navigate vast academic content, receive research suggestions tailored to their interests, and be guided through each step of their research journey.

ARC situates within the broader context of AI applications in education, emphasizing the growing role of personalized learning systems. ARC integrates collaborative and content-based filtering to provide dynamic and relevant research recommendations, allowing students to work more efficiently. The system adapts to ongoing user interactions, ensuring its recommendations evolve to meet the academic needs of each student. The platform also includes features like manuscript drafting assistance and interactive Q&A, making the research process more engaging. This is particularly relevant in engineering disciplines where research demands are high.

Feedback highlights ARC's ability to improve research efficiency, though users suggested expanding the recommendation system's precision. Overall, ARC holds significant potential to reshape the undergraduate research landscape by providing a more accessible and tailored approach to research activities, promoting innovation, and offering dynamic tool for students in engineering education.

[5] Lubom´ır Jamečný, Oleksii Yehorchenkov, and Nataliia Yehorchenkova examine how chatbot technology is changing the classroom setting in higher education institutions (HEIs) in their 2023 report. Their study highlights the need to update conventional teaching methods, which frequently fall short of meeting the demands of Generation Z students who seek quick and engaging learning opportunities.

To address these challenges, the authors present the "Digital Professor" chatbot, which uses the Telegram platform to automate processes like quiz grading, course material distribution, and round-the-clock access to learning materials. This invention is indicative of larger patterns in the digital revolution in education, especially in intelligent learning settings that utilize AI-powered tools.

In contrast to typical chatbots, the "Digital Professor" serves as an efficient learning management system (LMS), giving students access to a variety of resources, homework, assessments, and gamified educational opportunities. Positive feedback from Kyiv National University students highlights the tool's ease of use and its potential to enhance educational experiences in HEIs through advanced AI capabilities. Even though the cur- rent version relies on button-based navigation, conversational AI elements are anticipated to be included in future releases.

[6] With an emphasis on ChatGPT, Samuli Laato, Benedikt Morschheuser, Juho Hamari, and Jari Björne's2023 study explores the revolutionary effects of large language models (LLMs) in education. It charts the evolution of LLMs from the launch of the Transformer architecture in 2017 to Open AI's development of GPT models. With features like text and code generation, summarization, and interactive dialogue, systems like ChatGPT—which are built on LLMs—allow students to access expert-level knowledge and participate in reflective learning.

The authors evaluated ChatGPT's impact over a two- month period in order to perform practical examination of its role in a computer science Bachelor's degree program at a Finnish institution. They list 13 important ramifications, such as the improvement of critical thinking abilities and possible hazards, such as an over-dependence on AI to write code and essays. Although ChatGPT has several benefits, the authors also highlight some drawbacks, like its propensity to" hallucinate" or generate inaccurate information. They address moral dilemmas, such as plagiarism, and advocate for a well- rounded approach to AI-assisted learning, emphasizing the significance of responsible integration in academic settings.

[7] Artificial intelligence is revolutionizing the educational environment at very rapid rates, accompanied by tremendous benefits and many challenges that come with it. There are five areas in which the challenge cuts across: user experience, operational demands, environmental impact, technological limitations, and ethical concerns. Systematic problems can be handled using a review process in formulating an explicit research question, thus leading the criteria for selecting relevant literature. Firstly, will be the preliminary planning which includes finding of keywords to form a strategy for retrieving relevant studies within the largest and most established academic databases including Science Direct, IEEE, and Scopus .Using the inclusion/ exclusion criteria in filtering article selections based on focus relevance, and date of publications, anal most impossibly large pool will be shrunk down into aslightly more manageable size of only the highest-quality studies.

Three stages are found in review. The planning phase summarizes the research aims and criteria for inclusion and exclusion of an article. Articles are sifted through a multi-step protocol in the execution stage: keyword searches followed by screening of titles and abstracts, then full-text reviewing. Quality assessments ensure the study's relevance and rigour, further narrowing the selections to those with high levels of quality to be included. The final stage synthesizes the findings into categorized themes of challenges and

strategies, providing a structured overview of the key obstacles and actionable recommendations on AI use in educational settings. Thus, this systematic review framework is robust enough to be explored in AI's role in education and its implications.

[8] A structured approach to safeguarding implementation that deals with the ethical issues in large language models was proposed. In this proposal, it utilizes the MECE principle: it categorizes three broad areas so that it comprehensively and systemically addresses each ethical challenge: it starts with review ethics codes across professions; the nassessesethics awareness within computer science; then pin points where the LLM system safeguard points lay.

It breaks the LLM lifecycle down into upstream and downstream, explaining where ethical interventions come most into play. Controls such as input controls that operate through careful data curation are significantly effective for the avoidance of ethical risk but are usually abandoned because they raise transparency issues. Whereas controls that are further downstream like output filtering are being applied much more widely as it is cheaper and less resource-intensive but not so effective atthecore of addressing the ethical issues. Such an approach supports the notion of a proactive regulatory framework promoting responsible AI practices as LLMs are gaining fast adoptions.

[9] Differential Evolution based Fine-Tuning (DEFT) can optimize selection of layers in transfer learning for CNNs. DEFT is used for addressing challenges in fine- tuning efficiently, especially in areas such as medical imaging where large datasets are not available. Trans-fer learning enables pre-trained models that have been trained on vast datasets to be adapted to new but related tasks. However, choosing which layers to fine-tune in a CNN is not an easy task.

As empirical approaches are mostly not generalizable across tasks, deft employs the DE algorithm to do the layer selection automatically. Each candidate solution in the DE algorithm corresponds to a unique configuration of fine-tunable layers. The DE algorithm iteratively optimizes these configurations by training the CNN using a subset of target dataset and then analyze performance based on a fitness function, specifically categorical crossentropyloss. DEFT's adaptive layer selection mechanism identifies the best combination of layers. It involves striking a compromise between keeping generic features of pretrained layers and customizing them for the intended goal. This automated adaptive approach helps DEFT outperform traditional manual fine-tuning techniques in performance and reduces trial and error in layer selection.

[10] A mixed-method approach combining qualitative as well as quantitative techniques is used to analyse generative ais impact in education. Qualitative methods include case studies that observe how ai is being used for educational purposes in real-life, examining both benefits such as developing critical thinking and challenges such as educators resistance to change. Surveys and interviews are taken along with issues related to reliance on ai and privacy. Concurrently, through sources such as YouTube there is an understanding of peoples views related to the issue of ai in teaching. On the quantitative side, it keeps an eye on current studies in the sphere of ai for educational puposes to pinpoint key areas and track emerging technologies. The analysis by topic modelling further reveals public discourse on ai in education and evolving themes. The study further concludes that ai will make collaboration and critical thinking easy but should complement traditional teaching methods. Although it brings about personalization of learning opportunities, it raises ethical concerns about data collection and biases within the algorithms. Teachers beliefs and technological competency will influence their readiness in adopting ai for learning. AI should be used responsibly in education taking into account ethical concerns, teacher empowerment and the evolving role of AI inclassroom.

III. DISCUSSION

The ten examined papers show notable advancements in the use of AI-driven technologies and large language models (LLMs) in research and teaching. The creation of generative LLMs like ChatGPT, which are revolutionizing higher education by improving student learning experiences and offering educators cutting-edge resources, is one of the major developments. Research on the use of chatbots and LLMs in academic contexts, such as those conducted by Yehorchenkov etal. and Laato et al., highlights the tools' capacity to automate chores, promote critical thinking, and increase accessibility to learning materials.

The literature is replete with issues like an excessive dependence on AI-generated content and moral dilemmas. The necessity of responsible AI use and regulatory frameworks is covered in papers like Berengueres (2024) and Wong and Looi (2024), which emphasize the significance of data quality, system openness, and ethical safeguards. Furthermore, Vrbanci c and Podgorelec's exploration of adaptive fine-tuning is recognized as a crucial strategy for enhancing LLM performance

in specialized fields like medical imaging and teaching. These developments suggest that LLMs will eventually be extensively in corporate into research and educational settings, encouraging creativity while also needing rig- orous evaluation of practical and ethical issues.

IV. CONCLUSION

The developments in LLMs and AI-powered learning tools covered in this review demonstrate the increasing influence of these resources on research and higher education. AI-assisted learning platforms, chatbots, and adaptive fine-tuning are improving student engagement and expediting academic procedures. But there are important issues that need to be addressed, including moral dilemmas, the danger of relying too much on AI-generated material, and the requirement for strong regulatory frameworks.

Future research should concentrate on improving LLM performance, especially in domain-specific applications, ethical protections, and responsible AI use. Maximizing the advantages of these technologies in education and beyond will also need strengthening integration with current educational systems and creating plans to balance AI and human involvement.

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