Exploring Opportunities and Challenges of AI-incorporated Biomedical Informatics Education: A Qualitative Study*

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***Abstract*— This article presents a case study on the integration of AI as a teaching and learning tool in a biomedical informatics course for college education. The article details the design of the course and its methodology, including hands-on learning, in-class activities, and weekly assignments that utilized AI tools. An exploratory qualitative study was conducted with six college students to learn their perceptions and learning experience with this AI-incorporated course. We applied thematic analysis approach to investigate the opportunities and challenges of integrating AI in college education. The course generated positive outcomes, highlighting the potential of AI tools in education and the importance of hands-on learning and critical thinking. The results of thematic analysis agree with that AI allowed students to more efficiently engage in metacognition. The article concludes with a discussion on the implications of using AI in education and the need for continued exploration and assessment of their impact on student learning and success, for example, AI-human collaboration, scaffolding support for AI-incorporated education, and students' expectation for reliance on instructors. Overall, the study course provides a case study of a novel integration of emerging AI tools and education in biomedical informatics, showcasing the potential for personalized and efficient learning experiences.**

I. Introduction

Since the release of ChatGPT in November 2022, there has been a trend of rapid development in AI technologies as well as heated discussions about the use and integration of AI in academic research and education [1,2]. ChatGPT has demonstrated impressive capabilities such as passing exams, writing essays, producing computer programs, and responding to a wide range of topics [3-7]. However, the power of AI has also raised serious concerns regarding plagiarism, which threatens the fundamental mission of education- enriching human judgment through creative problem-solving. The U.S. Department of Education recently released a report emphasizing the necessity of addressing the role of AI in education to prevent the perpetuation of biases and inequities [8]. While AI holds great potential for enhancing personalized learning experiences, it is crucial to ensure human involvement and use AI as a complement to teachers and schools. Additionally, students should be equipped with knowledge and skills to understand, critically evaluate, and actively engage with AI, while policies and standards establish guidelines for its ethical use. Collaboration among the education, innovation, research, and policy sectors is essential to align the implementation of AI with broader education objectives. Many educators have raised questions about the potential impact and influences of AI on education from K-12 to college [1,2]. To explore the potentials and limitations of AI in the classroom, the authors designed a course on biomedical informatics using AI tools and conducted an exploratory qualitative study with students to learn their perceptions of and attitudes towards integrating AI tools in their coursework. This demo article presents the results of the course as a case study, including the instructor's experiences, lessons learned, and questions for further discussion. This biomedical informatics course focuses on medical informatics, AI, and robotics in the biomedical engineering program.

II. Methodology

A. AI-incorporated Biomedical Informatics Course

The instructor used ChatGPT to design a 15-week biomedical informatics course in an inverted classroom format. The instructor integrated ChatGPT into the course material and used it to facilitate student learning and evaluate their performance. Students were asked to create materials using ChatGPT, prepare and deliver presentations, and engage in in-class activities such as discussions, brainstorming, and reflection. The course includes weekly assignments, capstone projects, and various hands-on activities. In each class, students presented their work, engaged in debates and discussions, brainstormed ideas for the next classes, and reflected on what they have learned, challenges they faced, and how to improve their learning. The following subsections offer a detailed look at two carefully selected weeks from the course, serving as illustrative examples of its intricacies and structure.

Example Weekly Assignment 1: 1) Use AI tools to create materials for a 5-minute presentation on the introduction of medical informatics for an audience of high school students. Make sure you understand the basic concepts generated by the AI tools and that you are able to explain them in your own words. 2) Research and review available AI tools that are relevant for medical informatics. Test the tools if possible and prepare to introduce one tool to the class. Since your peers may introduce the same tool, try to do a comprehensive preparation to ensure you are presenting unique and valuable information. 3) Come up with suggestions for in-class activities for future classes and share them with the class and instructor. 4) Reflect on your learning process by sharing the pros and cons of using AI tools and make suggestions for improvement."

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In-class activities involved pedagogy discussions and feedback on teaching styles. Students delivered a 5-minute presentation on medical informatics for high schoolers, then engaged in a discussion about using ChatGPT for presentation prep, exploring its impact on learning and the potential for AI to personalize education. They also pondered AI's role in fostering homogenous learning. Experiences with AI tools like ChatGPT and DALL-E 2 were shared and brainstorming sessions for future projects were held, including designing AI chatbots, analyzing models, hosting guest speakers, conducting open forums and discussions, and devising clinical support teams. Students also examined career prospects and discussed ethical issues in AI-assisted healthcare.

Example Weekly Assignment 2: Choose a research topic and use ChatGPT to develop a tangible solution to a problem. The project topic chosen did not need to be the students' capstone project.

In-class activities included hands-on learning, where students engaged with AI tools to analyze diverse medical data such as electronic health records, images of medical scans, and speech data from patient interactions. The instructor facilitated reflective learning and urged students to contribute novel insights. Students shared their experiences, challenges, and suggestions on sharpening critical thinking with AI tools. Some students sought clearer instructions and guidelines for complex tasks. Addressing these requests, the instructor set up a live online forum for class communication and promoted the idea of minimal viable product concepts.

B. *Exploratory Qualitative Study*

A questionnaire survey was distributed to students, to learn their perceptions of and experiences with the application of ChatGPT in teaching and learning. The survey included five open-ended questions, including *Q1*: How often did you use ChatGPT during the course, and for what purposes? *Q2*: Did you receive enough guidance and support in using ChatGPT for your assignments/projects? *Q3*: How did using ChatGPT impact your learning experience and outcomes in this course? *Q4*: Did ChatGPT enhance your critical thinking skills or creativity? If so, how? and *Q5*: What are your suggestions for improving the use of ChatGPT in future courses? The study was approved by the Institutional Review Board (IRB) (IRB number: UTK IRB-23-07400-XM). Six students (2 female and 4 male) in this class participated in this survey study, including 1 junior undergraduate, 4 senior undergraduate, and 1 first-year PhD student.

B. *Data Analysis*

Students' responses were firstly deidentified by removing identifiable information, such as the instructor's name. Then we applied induced thematic analysis approach to learn students' perceptions and perspectives. Specifically, we firstly used GPT4 to suggest themes or topics and two human coders compared and finalized the themes and subthemes, ensuring that there would be agreement between the coding results.

III. RESULTS

Four students mentioned using ChatGPT quite or fairly frequently for this course, while two students using it not that frequently. The purposes or applications of ChatGPT among students are presented in the bar plot, in Fig. 1, including learning and understanding new concepts, programming assistance, project support, presentation and content creation, and information retrieval and knowledge expansion. Noticeably, a student may mention several purposes at the same time. Students viewed ChatGPT as a support tool rather than a primary source for completing their work.

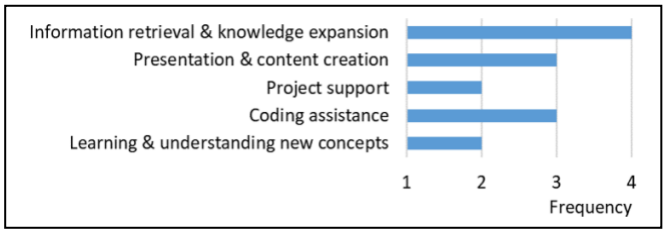

Figure 1. Frequency of purposes of using ChatGPT by six students.

Regarding if they have received enough guidance and support in using ChatGPT for their assignments and projects, three students clearly said yes while one student felt s/he only received partial guidance (Table I). See Table I for more detailed students' perceptions of the guidance and support for using ChatGPT in their coursework. Additionally, Tables II, III, and IV show the results of the thematic analysis on students' responses to Questions Q3, Q4, and Q5, respectively. ChatGPT contributed to student learning in myriad ways: streamlining, programming, and brainstorming, etc., as presented in Table II. Students also expressed their concerns on the limitations, reliability, and trust issues of ChatGPT.

TABLE I. STUDENTS' RESPONSES REGARDING IF THEY RECEIVED ENOUGH GUIDANCE AND SUPPORT IN USING CHATGPT IN COURSEWORK

Main Themes	Subordinate Themes	Examples
Guidance & support	Adequacy of guidance (n = 4)	"I would have appreciated more guidance and support in learning how to write code related to ML"
	Instructor involvement	"…Dr. {Instructor's name} provides plenty of detailed explanations and examples that explain to students how to properly prompt ChatGPT"
	User-friendliness of ChatGPT	"ChatGPT is exceptionally user friendly and is even able to provide instructions on how to best use it if prompted"
	Probing ChatGPT	"ChatGPT would omit important details, but more often than not, I could recognize this and essentially request more details"
Exploration & limitations	Familarity with natural language processing	"It is our first time exploring the world of NLP algorithms and so I will say, I did not receive enough guidance and support because we all have training wheels in this space"
	Learning curve for using ChatGPT	"I became very familiar with the functions of ChatGPT… However, it is still challenging to fully grasp the capabilities and use them appropriately"
	Struggle with using AI-generated content	"There was one scenario where it did not explain a certain detail about some code that it generated, which then led to a problem that took me a while to find"
Integration of ChatGPT in coursework	Balancing AI help with originality	"What is allowed and what is not allowed, where is the line between coming up with your own work and using AI assistance"

TABLE II. INFLUENCE OF USING CHATGPT ON STUDENTS' LEARNING EXPERIENCES AND OUTCOMES

Main Themes	Subordinate Themes	Examples
Learning process & efficiency	Streamlined learning process	"ChatGPT has allowed me to streamline my learning process for this course"
	Increased understanding of topics	"I was able to quickly get a much better understanding of many of the topics discussed in class"
	Improved programming skills	"I have learned a great deal about programming fundamentals…"
	Enhanced engagement	"Using ChatGPT has made learning in this course more engaging and fruitful"
	Trial and error with AI prompts	"The way I design prompts to provide me with higher quality answers is something that has taken mindless trial and error but has been very rewarding…"
Project development & support	Planning capstone thesis	"ChatGPT has been most beneficial in the brainstorming process involved with forming a capstone thesis"
	Development of final projects	"It really helped me develop and learn how to develop certain parts of my final project"
	Assistance with coding applications	"… helping with various coding applications and also very informative for the medical informatic applications…"
Impact on motivation & work ethic	Demotivating due to easy access to answers	"I believe ChatGPT has demotivated me to do more work. When I know that I can access most of the general answers with one click, I tend to put off work"
	Procrastination	"Normally if a project or assignment is more definitive with multiple milestones and deadlines it is easier to be motivated to get assignments done"
Limitations & challenges	Difficulty learning complex coding	"However, I find it difficult to learn this complex method of coding and training using AI tools only"
	Need for hands-on experience	"… There is no book that will teach you how to effectively place your weight on the board, you just have to do it and let your body's instincts take over"
	Correct tactics & queries	"… ChatGPT has a lot of potential to be a great fact teacher with the right approach (questions to ask)."
Future AI usage & expectations	Increased comfort & confidence in using AI tools	"After having used ChatGPT extensively, I have become much more comfortable and confident using the tool to accomplish various tasks, including troubleshooting code"
	Future AI use	"The way I design prompts… has been very rewarding as I consider my use of AI in the future"
	Task delegation	"ChatGPT has helped me overcome the technical and more grueling aspects of this course"
Critical thinking enhancement	Fact verification	"When ChatGPT told me something, I would have to think about areas where it might not have told me everything"
	Deep understanding	"Based on basic suggestions... I was able to... continue asking more narrowly focused questions"
	Problem-solving	"This also helps me come up with more creative solutions that ChatGPT had not suggested before"
Dependency & misuse concerns	Over-reliance	"ChatGPT has the potential to 'hallucinate' and if students rely on ChatGPT to do their critical thinking for them"
	Time mismanagement	"I more was able to put things off knowing that with ChatGPT I will be able to finish assignments faster"
	Potential misuse	"This tool has served as an easy solution that I can just cut and paste into whatever problem or assignment I am working on…"
Learning curves & personal circumstances	Adoption difficulty	"When you have a tool that can answer any almost question... it is hard to grasp at first…"
	Individual Circumstances	"I have had a very hectic semester and academics have taken the back seat to deal with family challenges…"

TABLE III. STUDENTS' PERCEPTIONS OF CHATGPT ON THEIR CRITICAL THINKING SKILLS OR CREATIVITY

Main Themes	Subordinate Themes	Examples
Creativity enhancement	Idea generation (n = 4)	"ChatGPT is fantastic at producing a bunch of ideas or examples for a particular topic"
	Prompt creation	"I have become much more creative in my prompt generation"

TABLE IV. SUGGESTIONS FOR IMPROVING THE USE OF CHATGPT IN FUTURE COURSES

Main Themes	Subordinate Themes	Examples
Learning assistant	Individual learning support	"It may be more suited for individual assignments, like homework, since it is characterized by one-on-one conversations."
	Overcoming learning obstacles	"… be a tool for students to overcome the more tedious and frustrating aspects of engineering, such as long coding projects"
	Enhancing knowledge application	"When students do not have to spend hours on end wondering why their programming doesn't work, they are able to think more about how to use these system to make real changes in the world."
Course structure & Guidance	Defined learning objectives	"If there are concrete objectives and testable material, it will really direct students to use their time wisely and will allow them to see the end destination for the course"
	Guidelines for AI usage	"I would like to see some guidelines implemented in the AI usage, and not the restrictive type of guidelines but rather helpful that will become the basic approach to the AI tool"
Future-proof skills	AI prompt engineering	"… maybe help teach students about 'AI prompt engineering', especially pertaining to ChatGPT, to help get the user the optimal/ desired output"
	Prepare for AI integration	"It would be wrong to ban ChatGPT completely from courses because you would be depriving students of a very useful tool"
Encouraging critical thinking	Avoiding overreliance on AI	"I think students should be advised against relying on answers produced

		by ChatGPT and encouraged to use it as a tool to help them reach answers"
	Enhancing coursework complexity	"Assignments can become more detailed and complex, accounting for the time students would save by using ChatGPT"
Role of Instructor	Instructor experiment-ation	"I think professors would have to put their own effort and judgement as well as experiment with ChatGPT personally in order to best decide how they might alter their assignments to better engage their students and teach the material for their course"
	Structuring learning experience	"I think that course structure will be essential and that is just going to take experience on the part of the professor to know how to guide students through exploring and understanding ChatGPT and tools like it"

IV. Discussion

The results of the exploratory qualitative study demonstrated the potentials of emerging AI tools, ChatGPT, in education and identified challenges in such an AI-incorporated education, suggesting the need for continued exploration. The course generated positive outcomes, as students were able to learn medical informatics, engage in productive in-class activities and reflected on the pros and cons of using AI tools in the classroom, and develop critical thinking skills using AI tools (Table III). As presented in the results of the thematic analysis, the use of ChatGPT allowed students to more efficiently engage in metacognitive activities (Fig. 1 and Table II), for example, using ChatGPT for brainstorming, setting project goals, making plans, gathering resources for solving the problem, experimenting/attempting to solve the problem, monitoring progress and evaluating the quality of the solutions, creating effective presentation, and reflection, etc. Students have also used ChatGPT to deal with complexity of problems or concepts they encounter, assist coding, enhance the creativity of their projects, and therefore promote their task efficiency. Moreover, ChatGPT has offered an opportunity of providing students with a personalized learning experience and tool (Tables II and IV).

Moreover, students emphasized the importance of AI-human collaboration in problem solving. Students mentioned that ChatGPT might omit important details and they would essentially request more information from ChatGPT (Table I). Although that ChatGPT provided access to information, students realized that it still took human effort to integrate knowledge for solving complex problems (Table II). Therefore, to get more accurate or more detailed information, human needs to intervene with ChatGPT.

The responses collected from students also suggest challenges of incorporating ChatGPT in college education. While ChatGPT promotes independent learning, some students did not feel comfortable with this type of learning and asked for a more scaffolded learning experience. For example, students indicated the challenges of understanding and implementing AI-generated content (Table I). They also pointed out the need of more guidance related to machine learning (Table I), hands-on experience of and the right approaches of using it (Table II), and their expectations for reliance on the instructor (Table IV). In future education, educators need to take these concerns seriously into account. Students' comments (Procrastination in Table II and Table IV) emphasize the importance of scaffolding support [5] for education, i.e., the support given during the learning process tailored to the student's needs. The dramatic development of AI pushes us to reform and innovate higher education in its content and pedagogy. As the use of AI tools in the classroom continues to evolve, it is essential to assess the implications for student learning and to develop appropriate guidelines for using such tools.

The current study has limitations. Our research involved only six students, limiting our findings' scope. To gain a more comprehensive understanding of AI-integrated education, our next step is to increase our sample size and incorporate perspectives from other stakeholders. Additionally, this work solely focused on the application of AI in college-level biomedical engineering education. In future investigations, we plan to delve into the potential and address the challenges of AI integration across different levels and fields of education.

Disclaimer

This paper represents the collaborative efforts of the authors. The course was designed and taught by XZ. The survey questions were designed by AM and XZ, and the survey itself was administered by XZ. The survey results were analyzed by FY, AM, and XZ. Finally, the paper was written by FY, AM, and XZ. Although the paper has undergone proofreading using ChatGPT to enhance its readability, the responsibility for the accuracy and content of the paper lies solely with the authors. The involvement of ChatGPT in the proofreading process should be understood as a tool for linguistic assistance rather than as a contributor to the research and findings presented in the paper.

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