

Student Perceptions of Artificial Intelligence Utility in the Introductory Chemistry Classroom

Published as part of the Journal of Chemical Education *virtual special issue* "Investigating the Uses and Impacts of Generative Artificial Intelligence in Chemistry Education".

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Cite This: *J. Chem. Educ.* 2024, 101, 3547–3549



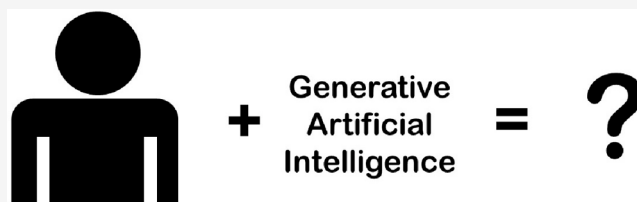
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ABSTRACT: This study investigates student perceptions of generative artificial intelligence (AI) in an introductory chemistry course. Students engaged with AI chatbots of their choice to correct missed exam questions, revealing overall positive attitudes toward their usefulness. Despite this positive perception, the study shows a disconnect between the overall media portrayal of AI in academia and how actual students use it. Only a small number of students had used AI before this activity. This study highlights the need for training on responsible AI use to address ongoing ethical



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KEYWORDS: *First-Year Undergraduate, General, History, Philosophy, Internet, Web-Based Learning, Learning Theories*

Generative artificial intelligence (AI) chatbots based on large language models have the possibility of greatly changing university classrooms. While AI has promised to change the future for decades,¹ the current version of AI chatbots represents a significant step forward regarding technological capabilities and broad use.²

AI also has a long history in chemistry, with some even predicting AI-assisted chemistry instruction in the 1980s.³ In the years that followed, using the term AI in chemistry generally referred to various forms of machine learning⁴ focusing on drug discovery.⁵ With the advent of GPT-4 and the other generative AI systems that followed, chemistry instructors have started investigating the use of AI in the classroom.⁶ These initial studies generally focused on the accuracy of such systems for answering chemistry questions. Showing the rapid rise in this technology, early papers in 2023 showed chatbot responses lagging behind students. Published in March of 2023, Fergus et al. saw that when ChatGPT provided answers, they were well written but no answers were provided for many questions regarding application and interpretation of concepts.⁷ Similarly, Tyson saw ChatGPT was having difficulty with math problems and making up references in July of 2023.⁸ However, by the end of 2023, the consensus was changing. Separate studies in September of 2023 acknowledge the strength of chatbots. Watts et al. point out evidence of mechanistic reasons in both student and chatbot writing,⁹ while Clark et al. show better problem conceptualization compared to students.¹⁰ However, as Leon and Vidhani point out, even if one of these systems can get the correct answer, they cannot always explain how they got to their answer, which

can cause significant problems when using them in an educational setting.¹¹

A major concern for faculty members from all disciplines is the misuse of such systems by students. While faculty display a range of reactions to the technology with some even using it to give student feedback,¹² a significant number are deeply concerned about abuse, especially in writing assignments.^{13,14} In contrast, students are very excited about the possibilities of generative AI.¹⁵ One recent study looked at how students are discussing large language models and ChatGPT specifically by analyzing content on TikTok, a popular social media platform aimed at people under 30. They found that a variety of topics, including promoting the use of AI to write essays and even how to fool AI detectors, but very little on the ethical or practical issues.¹⁶

Recent articles also reflect the growing reality that AI is here to stay and the best option is to explore effective uses in the classroom.¹⁷ Some such authors focus on responsible use, such as the article by Yang describing his approach of rethinking assignments to use ChatGPT and other sources as a starting point and assistant.¹⁸ Others such as Piunno and Shamuradyan seem to have accepted the availability of such tools and include a

Received: January 22, 2024

Revised: June 28, 2024

Accepted: July 3, 2024

Published: July 16, 2024



discussion of “appropriate and constructive use” in newly developed activities.¹⁹

Recent chemistry articles of the subject of AI have also moved on from the accuracy of such systems to how they can be used effectively in the classroom. Guo and Lee developed a strategy incorporating generative AI into introductory chemistry essay assignments to enhance critical thinking skills.²⁰ Alasadi and Baiz take this a step further and point to possible uses in personalized learning and real-time assessment.¹⁸ Suggesting the growing acceptance of AI tools, Exintaris et al.²¹ use ChatGPT as just one piece of a multipronged approach to improve critical thinking.

The study presented here investigates student perceptions of generative AI in an introductory chemistry course. It is natural for faculty members to be concerned about misuse; however, the first question educators need to ask is how students are actually using these systems. As others are starting to see, the AI revolution is not as black and white as some early commentators would have us believe.

THE EXPERIMENT

Over the course of the fall 2023 semester, one section (21 students) of an introductory chemistry course for science majors were tasked with using an AI chatbot of their choice to help correct test questions missed on tests. While the assessment of this activity was part of the course, students were given the option to opt-out of data collection for this study. Three times during the semester, after a test, students were told to choose a question they missed and use an AI chatbot to correct it. Furthermore, they were instructed to discuss what they believed the chatbot did well and what it did not so well. As many other authors have noted, there are lingering ethical and privacy concerns about how these chatbots manage user data.²² To alleviate some of these concerns for the students involved in this study, participants were instructed to only use the test questions supplied and written by the instructor as prompts. In this way, no student or potentially copyrighted information is being provided to the corporations that make these systems. Instruction in effective prompt writing is an important topic as discussed by Tassoti,²³ but falls outside the scope of this study. This study was approved by the Indiana University Institutional Review Board.

Students were shown an example during class of how to use these systems. A question from a recent quiz was used as a prompt in ChatGPT, and the response was discussed. At the beginning of this study most students were generally familiar with AI, however, only 19% reported ever using any form of it before this assignment. This is somewhat lower than a recent study that showed 49% of students at a wide variety of universities are using AI writing tools.²⁴ The discrepancy between this study and the literature could be due to the small sample size or the fact that, as a course of mainly first-year students, the students have not had the need to investigate the use of tools like this yet.

STUDENT REACTIONS

In addition to a discussion of each generated answer, students were given a short survey with three LIKERT questions and a space to offer general comments at the end of the semester (Figure 1, $n = 16$). Due to the rapidly changing nature of the field, a small sample size and limited scope of questions were accepted to ensure a timely report. When asked if they considered the answers generated by the AI chatbot to be

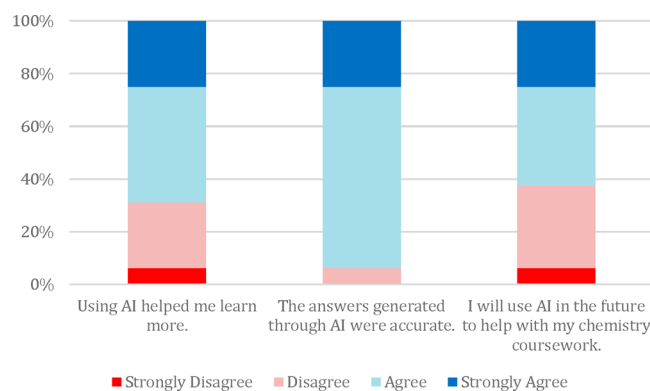


Figure 1. Student responses to a LIKERT survey regarding the use of generative AI during the semester.

accurate, the vast majority (94%) agreed. This result corresponds well with a review by the instructor that found no factual errors as well as recent literature showing the increased accuracy of these tools discussed above.^{9,10} While the students agreed that the answers were accurate, the percentage of students agreeing that AI actually helped them learn dropped to 69%. Still a clear majority, this shows that many students were still not convinced that AI was necessary even if it is accurate. This is further reflected by 63% of students saying that would use AI in the future to help with their chemistry coursework.

Most students chose to use ChatGPT (two used Bing Chat now called Copilot), presumably because this was generative AI receiving the most media coverage at the time of the study and it was used in the explanatory example before the assignment. Despite using the same system, the questions asked of it were a diverse mix of test questions. At the beginning of the study, it was assumed that students would choose the more conceptual questions over the analytical ones due to the text-based nature of generative AI. However, students quickly discovered that it was equally useful for problem-based questions. For example, when asked “How many atoms would be in 35 g of Selenium?”, instead of just outputting a value, ChatGPT gave a step-by-step breakdown of how it arrived at the answer. Many students commented on the survey that they liked how detailed the answers were.

The level of detail in the answers was helpful for most students, but others described the answers as longwinded or difficult to interpret. These students commented that while they could not find anything factually wrong with the answers, the core point was sometimes lost in somewhat rambling answers. Comments such as “it [the answer] is quite lengthy and unnecessary to include a bunch of extra information that the question was not asking” and “it could also explain differences of acids and bases in simpler terms” were more common for long answers from more complex problems. These types of answers looked more like examples from a textbook than student work. This result suggests that generative AI may still have difficulties tailoring answers to the user’s prior knowledge without an additional prompt.

Four students also noted some existential dread when using these systems. One particularly pessimistic view expressed by a student was that generative AI “will probably make your [the instructor’s] job redundant someday...maybe mine too”. Overall, the comments seem to reflect the ongoing discussions on the promise and peril of AI systems in general.

LIMITATIONS

The primary limitation of this study is the small number of students who chose to participate (16) in the survey. Due to this small sample size, only students' reactions to the use of AI were investigated. Larger studies should be conducted on the effective crafting of inputs to AI systems and how student learning is affected by the incorporation of AI assignments and activities.

CONCLUSIONS

Overall, students in this study have a positive view of the utility of generative AI chatbots in this chemistry course. While the sample size of this study was small, the findings do correlate with recent studies about the accuracy of this new generation of AI chatbots.^{9,10} Additionally, nearly all students felt the answers were correct which was confirmed by the instructor. Fewer students, but still a clear majority, said that these systems were helpful and that they would continue using these tools in future classes.

From the instructor's point of view, this exercise provided a method to both reinforce some difficult concepts from the course while also introducing a new technology. For instructors considering incorporating generative AI into their classrooms, one important piece of information discovered was that while this technology has been heavily discussed in the media and academic journals, not all students are familiar with it. As the results discussed above show, only a small percentage of students had used AI in some way before this activity. While this will undoubtedly grow over time, it cannot be assumed that all students are using AI in their daily lives. Now is the best time to have discussions about proper use before any bad habits have time to develop.

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Notes

The author declares no competing financial interest.

ACKNOWLEDGMENTS

The author would like to thank the students who participated in this study.

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