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Using ChatGPT in the Calculus Classroom

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Abstract

The integration of artificial intelligence (AI) into higher education classrooms is increasingly widespread and, in many cases, unavoidable. In particular, the use of ChatGPT represents one of the first approaches of AI within the classroom setting. It is a tool that students find appealing, and its usage has rapidly gained popularity to such an extent that its presence in the classroom is unavoidable. For students, its use feels natural, and if applied properly, it can significantly enhance learning. It offers time-saving advantages and can support learning in various ways, tailored to the needs of each student. For educators, it presents an opportunity to connect and communicate with their students, foster educational innovation, improve class organization, and promote the ethical and critical use of technological resources.

This paper presents an in-class experience within a Calculus course, a core subject for undergraduate students across various engineering disciplines. The activity involved conducting a search for optimization problems in three different ways, progressively refining the queries to make them more precise. Following this process, students were asked to reflect on the overall experience.

The activity was well received and appreciated. In their reflections, students recognized that simply asking questions is not enough; the questions must be well-directed, analyzed, and carefully phrased to obtain the desired outcomes. They also noted that textbook problems are generally easier to solve than those provided by ChatGPT, as the former are more clearly defined.

The overall experience was positive and well accepted, but it also prompted thoughtful reflection on the use of such technological tools in education.

Keywords: *Educational innovation, ChatGPT, higher education, Calculus*

1. Introduction

The integration of artificial intelligence-based technologies, such as ChatGPT, is rapidly transforming various sectors of society, including the field of education. These tools, capable of generating text, answering questions, and simulating human conversation, have begun to be used by university students to support their academic activities. In particular, engineering students who have given their profile focused on innovation and problem-solving tend to show a special interest in experimenting with these emerging technologies.

In the classroom, the use of ChatGPT has sparked both interest and debate. On one hand, it represents an accessible tool for consulting information or drafting texts; on the other, it raises pedagogical challenges, such as the routine use of its responses or the frequent reliance on it for automated solutions. In this context, the teacher's role becomes increasingly important in guiding students not only to use these technologies but to do so critically and reflectively.

Undoubtedly, the use of ChatGPT can be part of educational innovation at any level; its integration is particularly necessary given that students are already using it on their own.

Among the various ways in which instructors can use ChatGPT—beyond simply searching for information—are the following:

- Discovering resources to use in class
- Designing innovative learning activities
- Planning complete lesson structures
- Translating academic content
- Creating ad hoc visual materials
- Assisting with programming and code development
- Providing tutoring or guidance on specific topics
- Generating sets of exercises on specific subjects—in this case, particularly in Mathematics
- And many others

The most significant challenge for educators is to incorporate AI into the classroom in a way that motivates students and positively impacts their learning. Ideally, tools like ChatGPT should be used to foster critical thinking, promote reflection on search processes, and encourage ethical use both in terms of how the tool is applied and how its results are interpreted.
This study proposes a classroom experience with the primary objective of having students analyze different prompts used with ChatGPT, evaluating how the formulation of questions influences the quality and depth of the generated responses. Through this activity, the aim is to foster critical reflection on the use of such tools, promoting skills such as interpretation, information evaluation, and the ability to improve their own inquiry and learning processes.
The paper begins with a literature review, offering a current perspective on available research and pedagogical approaches. It then describes the methodology, detailing the specific steps followed to implement this AI-based activity. A summary of the students' reflections and findings is presented, followed by the overall conclusions drawn from the experience.

2. Literature Review

For many years, the classroom remained largely unchanged. However, the arrival of more affordable computers, followed by laptops and then the Internet, gradually led to the inevitable integration of technology into schools and universities. The use of such technology is no longer optional [1]; it is now considered a vital resource for learning and part of the preparation required for graduates entering the workforce. Technology helps students become more competitive and better positioned in the job market.
The use of technology and especially artificial intelligence has significantly increased since the COVID-19 pandemic. Its presence in the classroom is no longer optional; even if instructors choose not to use it, students will inevitably do so. This highlights the importance for educators to understand these tools and critically analyze what their use entails. Among the advantages that AI-based resources offer in education are [2]:

- Automation of certain tasks
- Access to tutoring on specific topics
- The ability for students to make mistakes in a non-intimidating environment
- Access to information beyond the classroom
- Reaching a wider audience

Despite these advantages, there are also areas for improvement, such as addressing the ethical implications of AI use and ensuring that it supports rather than replaces critical thinking.
Dempere [3] outlines some of the risks and disadvantages of AI use, including privacy violations, false information, unexpected outcomes, cognitive bias, reduced human interaction, and limited accessibility.
A major advancement in this area is the emergence of tools like ChatGPT. Students often begin using it even before it is introduced in the classroom, which presents a challenge for educators: how to use it meaningfully to enhance learning and with a clear educational innovation focus rather than merely for conducting searches. As Vera [4] notes, AI is advancing rapidly and has significant implications for teaching and learning.
ChatGPT has become a common resource in higher education. Students use it to ask academic questions, obtain quick answers, generate ideas, support writing tasks, and make more informed academic decisions [5]. However, this usage is sometimes somewhat disorganized.
This is where the teacher's role becomes crucial. Tools like ChatGPT should be used purposefully and critically, with guided strategies to ensure consistency in the responses obtained [5]. It is especially important that students learn to ask well thought out, analyzed, and targeted questions so that they are not simply passive recipients of information. Once a response is received, students should be encouraged to analyze it, verify sources, expand upon it, and confirm its reliability.
As García [6] points out, students are indeed interested in using ChatGPT; they find it motivating and useful. However, they also recognize that the tool does not always provide fully accurate answers. A certain level of topic knowledge is required to assess whether the information is reliable and adds real value.
Deleón [7] suggests that such tools can support the learning process, but the results obtained must go through a validation filter and be scientifically verified, ensuring that users take responsibility for the information they rely on.

As for educators, rather than being displaced by this technology, they can help students use it effectively [8]. To perform efficient searches, it is essential to provide clear and specific instructions, avoid ambiguity, and, where possible, offer contextual information.
It is also helpful to specify the desired format of the response. One effective strategy is to break tasks into smaller parts, allowing for multiple interactions. This helps students adjust and refine their prompts until the desired answer is obtained.
The main challenge for educators [9] is to incorporate these tools in a critical and constructive way, as part of an educational innovation experience. This will require training to better understand the technical aspects and feel more confident using the technology.
Educators can begin by implementing small-scale activities in the classroom and should test these activities beforehand to understand what to expect and how best to guide them. As teachers, we must also walk our own learning path in AI.

3. Methodology

This study was conducted with three groups of undergraduate engineering students, totaling 58 participants. The course was Differential and Integral Calculus, a core subject required for all engineering majors. Among the participating programs were Civil, Biomedical, Mechanical, Mechatronics, Biotechnology, and Data Science Engineering, among others.
To address the topic of the application of derivatives in solving optimization problems, a didactic activity was designed that integrated the use of ChatGPT through the progressive formulation of three interrelated prompts. The activity was structured in three phases: an individual assignment, an in-class collaborative activity, and a final individual reflection. This topic was chosen because it is traditionally one of the most challenging for students in Differential Calculus.

3.1 First Phase: Individual Assignment

After covering the topic of optimization with derivatives in class, students were given an individual assignment to complete outside the classroom. This task had two parts:

1. **Selection of a Textbook Problem:** Students were asked to choose a problem from the textbook section corresponding to optimization. The aim of this part was twofold: first, to observe what type of problem students selected; and second, to encourage a general review of the different types of exercises related to the topic found in the textbook.
2. **Generation of a Problem Using ChatGPT with the First Prompt:** Students were also asked to generate an optimization problem using ChatGPT with the following prompt: *"Give me an optimization problem related to the topic (mentioned area of interest)."* The area of interest could be related to the student's engineering discipline or a personal hobby or activity. This approach allowed for personalized engagement and helped connect mathematical content with the students' individual interests.

3.2 Second Phase: In-Class Collaborative Activity

In the following class session, a group activity was carried out. Students formed teams, shared the problems generated by ChatGPT, and selected the ones they found most interesting.
They were then asked to analyze the problems generated, identify their characteristics, and discuss possible improvements. Based on this analysis, two additional prompts were applied:

- **Second Prompt:** *"Give me an optimization problem related to the topic (mention area of interest), with one dependent and one independent variable."*
- **Third Prompt:** *"Give me the previous optimization problem or a similar one related to the topic (mentioned area of interest), with one dependent and one independent variable, and that can be solved using a maximum or minimum." Add any other instructions you consider necessary for the problem to be well defined.*

After generating new versions of the problems, the teams compared the outcomes of each prompt and analyzed how the formulation of the questions influenced the quality and clarity of the responses generated by ChatGPT. Once the problem was clearly defined and unambiguous, students proceeded to solve it manually using the methods taught in class.
Finally, they also asked ChatGPT to solve the problem to compare both the process and the results.

3.3Third Phase: Individual Reflection

To conclude the activity, each student submitted an individual written reflection along with the final problem selected and worked on by their team. The reflection addressed the following questions:

- What was your experience in designing a problem with ChatGPT?
- Was it easy? Did you have to make multiple attempts?
- How did you arrive at the final problem?
- Were constraints necessary?
- Which problem was easier to solve: the textbook one or the one generated by ChatGPT?
- What is your general opinion on the use of ChatGPT for this topic?

Additionally, students were asked to create a digital presentation (PowerPoint or another format) that included:

- The problem selected by the team and the reason for its selection.
- The solution proposed by ChatGPT and the manual solution developed by the team.
- A reflective paragraph on the experience of generating and solving a problem using artificial intelligence.

4. Results

Regarding the outcomes of this activity, they can be considered positive. Students completed the task with enthusiasm, albeit with a certain degree of skepticism, as they later mentioned they were not accustomed to using this type of tool officially within the classroom setting. The activity felt novel to them because, in their usual search practices, they tend to enter a single prompt and accept the first response they receive; if the result is not satisfactory, they typically switch to a different tool.

What was new for them in this activity was the process of refining their initial search and incorporating more specific and detailed requirements. They also realized that not everything generated by the tool is entirely accurate. Since most students used the free version of ChatGPT, some of the solutions contained errors—something they were able to identify by solving the problems manually as well.

These errors were more common when they requested problems related to specific or uncommon contexts, such as sports, which are not typically found in standard textbooks. In contrast, the problems that were better constructed and more clearly explained were those that resembled the typical examples found in Calculus textbooks.

A summary of the opinions of students from the three participating groups is presented below.

The students' experience using ChatGPT as a tool to generate and solve optimization problems within the context of a Calculus class revealed both its potential and its limitations. Overall, students agreed that ChatGPT is useful for solving problems and verifying procedures if it receives precise and detailed instructions. However, they also noted that problem generation can become problematic when prompts are vague, as the AI tends to produce statements that are either inadequately challenging or contain incomplete information.

Despite these challenges, many students acknowledged the value of the tool in exploring applications related to their fields of study, appreciating diverse solution approaches, and receiving immediate feedback. Comparatively, textbook problems were found to be clearer, more aligned with the course level, and easier to solve.

This highlights the need to accompany the use of AI tools with sound pedagogical criteria. Finally, students emphasized that AI could enrich the learning process if used critically to understand its limitations and without replacing autonomous, formative learning. Table 1 presents a summary of the analysis of the students' opinions.

Table 1. Key Findings

Category	Main Observation
Usefulness of ChatGPT	It is useful for solving simple problems and verifying step-by-step procedures.
Limitations	It generates problems that are either typical textbook examples, overly complex, or contain errors if prompts lack clarity.
Comparison with Textbooks	Textbook problems are generally better aligned with the course level, easier to understand, and more structured.
Required	Detailed instructions are necessary to obtain appropriately formulated problems.

Category	Main Observation
Specificity Level	
Difficulty of Generated Problems	ChatGPT may produce problems that are either too simple or excessively complex.
Pedagogical Perception	AI is valuable as a support tool but does not replace human reasoning.
Applicability to Academic Fields	Some students were able to relate the problems to their areas of study, making them more relevant.
Metacognitive Learning	Students recognized the need to use AI critically and to validate its outputs.

5. Conclusions

The use of ChatGPT is appealing to students, and even if it is not used in class, they will use it outside the classroom whether to assist in solving exercises or to find information. Students already have prior knowledge and perhaps some experience using technological tools implemented in their courses.
Their perspective changes when they realize how differences in the prompts also lead to significant differences in the search results. They came to appreciate the importance of having clarity about what they want to obtain in order to give precise instructions, as the outcome depends on this clarity. When they have to submit an assignment and do not get the expected results from their queries, frustration arises, and it is easy for them to switch tools or resources.
There are still students surprised that the use of ChatGPT is allowed in the classroom. They consider it a tool they can benefit from, but not officially. It is often seen more as a plagiarism tool than as academic support [1]. However, it is necessary to change this perception and adapt it to the reality of what is expected from these types of tools that is, to promote analysis and critical thinking.

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