ChatGPT to Support Critical Thinking in Construction-Management Students

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Pilot Study - Development of Critical Thinking in Construction Engineering Students Aided by Artificial Intelligence.

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Abstract

Construction engineering education is constantly evolving and adapting to emerging technologies like artificial intelligence (IA). Generative AI applications have become a valuable tool in helping students better understand information. Although generative AI development has been ongoing for several decades, its importance in higher education, especially in fields like Civil Engineering and Architecture, has significantly grown in recent years. This study seeks to explore how generative AI can be effectively used to enhance the development of critical thinking skills. To achieve this, the AI program ChatGPT was introduced to civil engineering students at Universidad San Francisco de Quito (USFQ) to assist them in their learning processes. The study allowed for the evaluation of the program's impact on the learning process and, consequently, on the development of critical thinking skills. Through surveys, data were collected from students of different academic years, providing insights into their development of critical thinking under various circumstances, with a qualitative focus on their perception of implementing AI as a learning method. Additionally, the study analyzes potential factors influencing the relationship between AI usage and academic performance. Through this research, a comprehensive understanding of the implications of AI on critical thinking in construction engineering education can be achieved. This present study is still in an early stage, so the preliminary results allow us to get an idea of how AI can help develop critical thinking by being used to gather information, learn new content, and form one's own conclusions that have a strong and clear foundation.

Introduction

In civil engineering, architecture, and related construction fields, critical thinking is a fundamental skill that students must continuously develop. This skill enables them to analyze, evaluate, and solve problems thoughtfully and logically, making it an essential tool for overcoming technical challenges and making informed decisions in the complex and dynamic construction sector, where each project presents new challenges [1,2]. It is crucial for civil engineering students to develop critical thinking skills to facilitate questioning assumptions, identifying problems, and seeking solutions [3]. By fostering critical thinking, civil engineering students are prepared to successfully tackle future challenges and contribute to the development of safe and advanced infrastructures that enhance the quality of life for people and the environment [4].

This research was conducted at the Universidad San Francisco de Quito, specifically in the cost engineering class of the civil engineering program. Students were tasked with using generative

artificial intelligence as a tool to understand new topics and question the information provided by the AI application (ChatGPT) through questions that expand on the information and clarify the topic at hand. Often times, students face anxiety and stress due to high demand of work [5,6] and feel tempted to fins shortcuts. This intervention aims to use potential shortcuts to improve learning experience [7,8]. The assignment, guided by the instructor, involved extracting the script from a video explaining what Lean Construction is and, using ChatGPT, summarizing it and generating several questions to enhance understanding. This allowed students to comprehend and expand their knowledge quickly and concisely. Subsequently, they were given another video to repeat the task, but in this case, the video was about a construction project that employed Lean Construction without explicitly mentioning it, so students had to use questions to prompt the AI to use words indicating that this construction project used the Lean methodology or similar ones. Throughout the process, it was demonstrated how students executed and acquired skills related to critical thinking, reflection, problem identification, and solution seeking. Upon completion of the exercises, a survey was conducted on critical thinking and AI, and how they relate or assist. It was determined that during the project, different skills were learned, such as interpreting and analyzing information, and using artificial intelligence as a learning tool. The significance of this study lies in the adoption of innovative pedagogical methods that engage students in the subject matter, thereby maximizing their learning potential. Additionally, the current educational landscape embraces the integration of novel technologies to foster enhanced learning experiences.

Background

Artificial intelligence is a technology that has come into common use in education due to its applications in the learning process. Both in the United States and in Ecuador and other parts of the world, artificial intelligence is becoming an important and used tool by students, removing all cultural barriers that may exist in civil engineering in different countries [9,10]. AI is the part of computer science involved in the design of intelligent computer systems, i.e., systems that exhibit the characteristics related to intelligence in human behavior, such as understanding, language, learning, reasoning, solving problems and so on [11]. To achieve its objectives AI (artificial intelligence) elaborates a set of algorithms and models that can perceive and comprehend their surroundings, make decisions, acquire knowledge through experience and repetition.

The beginning of artificial intelligence is a moving target, and it depends on the writer and/or researcher as to the approximate date that is identified as the beginning of artificial intelligence as a field of study [12]. Artificial intelligence is a not a recent topic it that has been explored by professionals since the 1940s, and over the years it has advanced and developed more sophisticated approaches due to the increasing power of technology and the growth of available information. Artificial intelligence programs were later created around the 1960s to develop various tasks with more efficiency.

Recently artificial intelligence has become a highly relevant field of study and application, which is why it has found a wide range of applications in various fields, including education. This is where intelligence enters as an important tool for civil engineering, architecture, or in interdisciplinary work involving all construction field careers [13,14]. That is the key point of transition where artificial intelligence left the programming field and started to approach other fields. Using AI in education (AIED) has created new opportunities for designing productive

learning activities and developing better technology-enhanced learning applications or environments. [15]. The integration of AI and education will open up new opportunities to vastly improve the quality of teaching and learning. Teachers can benefit from intelligent systems that aid in assessments, data collection, enhancing learning progress, and developing new strategies. [15].

Chat GPT and construction engineering education

Education is a process related to teacher and student, where teachers can use different teaching methods so that students feel more comfortable, methods such as coffee breaks in exams to reduce stress, teaching methods such as the flipped classroom method for flexible teaching, or even in methodologies used during pandemic to ensure teaching reaches students more effectively. In this case, a third party is implemented in addition to the student and the teacher[5,6,16], another tool such as AI (artificial intelligence) could enter the equation. An artificial intelligence tool that has become common in the educational field is ChatGPT. ChatGPT is a generative AI that is designed to be able to generate new content or ideas and express it in real-time conversations. ChatGPT is a text-to-text generative AI compared to other generative AI models that are text-to-image (such as OpenAI's DALL-E) [17]. As it is said the responses obtained through ChatGPT in addition to offering new information, offer a characteristic aspect in the interaction, because it is humanized by the way in which answers simulate a conversation. This unique approach has attracted the attention of students in the process of doing tasks. Despite its success, ChatGPT has introduced new challenges and threats to education. With its ability to provide specific answers to user questions, it can be used to complete written assignments and examinations on behalf of students, leading to concerns about AI-assisted cheating [18].

The application of Chat GPT generates concerns but there should be considered some parameters related to how the person makes use of the resource. It is considered that a person who has prior knowledge and critical thinking skills will have a strategic approach to the information obtained by this means. For example, a person with a strong background in critical thinking will be better able to filter out inaccuracies and build upon the useful and helpful parts of the answers provided by ChatGPT.[17]. That is why the procedure in the use of artificial intelligence could be divided into two key steps, the first related to approximation with previous knowledge, where questions are formulated aimed at the search for accurate information, and the second related to a process of exploration where the information is analyzed and selected.

Engineering architecture and construction careers students' use different technological tools, even when working together make use of different technological tools, which is why they must adapt quickly to the new tools that are developed. However, about artificial intelligence, its applicability in the educational process is questioned, despite this artificial intelligence could be applied in different ways. That would facilitate certain methods in the learning process. ChatGPT could be used to make summaries, prepare study questions for an exam, provide information on a specific topic, give sources of research, among others.

Critical Thinking

Critical thinking is a term that is associated with cognitive ability and is a core skill that higher students should acquire. The expert panel members of the Delphi Report formally defined critical thinking as "purposeful, self-regulatory judgement which results in interpretation, analysis, evaluation, and inference, as well as explanation of the evidential, conceptual, methodological, criteriological or contextual considerations upon which that judgement is based" [19]. Curiosity and questioning are necessary characteristics of those who think critically as they always try to find answers to the questions they raise [20]. Critical thinking is one of the skills that are important in the profile of higher education students. Strong critical thinking skills are therefore considered essential if higher education students are to succeed not only academically but also within personal and professional domains [19,21]. Due to its relevance critical thinking skills should be developed among engineering students. For engineering education, the goal of teaching CT is therefore the application in engineering practice. The transferability of CT skills developed in a context-free environment has been questioned with scholars questioning the ability for learners to effectively apply abstracted or non-discipline specific CT skills in a discipline specific context [22].

To develop critical thinking, there is a set of core skills that must be acquired. According to Facione [23], the skills are the following ones: interpretation, analysis, inference, evaluation, explanation, and self-regulation. Referring to Interpretation as a process of understanding and making sense of information or texts. It involves identifying the purpose, context, viewpoints, implications, and possible multiple interpretations. Analysis involves breaking information down into its fundamental parts, examining the key elements and components, and understanding how they are related to each other. This involves the ability to identify patterns, connections, underlying assumptions, and implicit assumptions. Inference in critical thinking refers to drawing logical and reasonable conclusions based on the available evidence. It involves using reasoning in a particular way towards the general, and deductive reasoning goes from general to particular.

Evaluation aims assessing the quality, relevance, and reliability of the information, arguments, or sources provided. It involves critically examining the arguments presented and the methods used to support the assertions or conclusions offered. Explanation encompasses the ability to clearly communicate and articulate thoughts, ideas, and arguments in a way that is coherent and understandable to others. This includes the ability to provide reasons and evidence to support claims made. Self-regulation in critical thinking includes the ability to critically reflect on one's own thinking and assess its logic, coherence, biases, or weaknesses. It implies being aware of personal limitations and prejudices and being open to reconsider or modify one's own beliefs or points of view based on new evidence or arguments.

The project was applied using the module of Lean Construction. Lean Construction, rooted in the principles of lean thinking, is a management philosophy dedicated to maximizing value and minimizing waste in the construction industry. The Lean philosophy is about the improvement process focused on both the identification and subsequent elimination of waste, as well as the creation of value [24]. The Lean production approach also has the potential to be applied in planning, design, and construction projects. To describe an approach that minimizes waste in materials, time and effort in construction activities, the International Group for Lean Construction coined the term Lean construction (LC) [24].

Methodology

This present study is exploratory research aimed at qualitatively [25,26] measuring students' perception of the use of generative artificial intelligence (ChatGPT) in tasks focused on learning new topics and how AI usage contributes to the development of critical thinking in civil engineering students. Data was collected during the Fall 2022 semester from civil engineering students in the Construction Cost class, resulting in a total sample of n=18 students. To gather data, surveys were conducted to assess students' perception, obtaining qualitative data that allowed evaluating students' response to the use of AI and critical thinking. The survey consisted of open-ended questions about two main topics: the first set of questions allowed reviewing students' comprehension of a new topic using AI, while the second part of the survey aimed to report students' perception of AI and the development of critical thinking during the task.

Characteristics of the activity

To conduct the activity, the generative artificial intelligence application ChatGPT was introduced to 18 senior Civil Engineering students. Students were tasked with conducting research on Lean construction with the assistance of artificial intelligence, using a video script that explained this topic as reference. Then, they were asked to generate a summary of the topic using AI. Subsequently, students were requested to generate questions of interest to expand their knowledge and clarify doubts about any part of the summary they deemed important. Afterward, students were asked to explain the topic in detail to analyze the acquired knowledge and the rationale behind their questions to the AI. The exercise was repeated with another video script, in this case about a building that utilized Lean construction, although the video only showed how the building was constructed and interesting data about it. In this case, students were asked to generate a summary using AI and, through questions, guide the AI to deduce that the building used Lean construction. Once the task was completed, students responded to a survey that allowed qualitatively measuring their comprehension of the class topic and their perception of the development of critical thinking when using AI. The obtained results included relevant data to quantify the effectiveness of a learning process aided by artificial intelligence in the development of critical thinking.

Data Analysis

The responses obtained through the surveys were carefully analyzed to determine the advantages and disadvantages of applying artificial intelligence in the learning process. The responses were grouped through a process where similar ideas were sought, grouping the responses to each question using a color scale, and the main idea of each grouping was extracted to determine the qualitative perception of students about the performed activity. This classification allowed identifying three main ideas about how artificial intelligence promoted critical thinking in students.

Results and discussion

The results of this exploratory study showed us how students perceived and used artificial intelligence in the learning process to achieve the development of critical thinking skills.

Method to obtain and interpret information: Students reported that the application of artificial intelligence helped them obtain concise information. One student said, “The use of

artificial intelligence tools allows presenting the main ideas of the topic concisely and quickly." Additionally, the use of artificial intelligence helped synthesize information, as students responded, "Chat GPT helps synthesize video information in seconds." The information also allowed students to interpret it to understand the topic. One student said, "The advantages are that it gives you the information you are looking for instantly and is easy to understand."

Analytical thinking: Students' self-reported answers suggested that the use of artificial intelligence allowed analytical thinking. ChatGPT became a tool that stimulated question formulation to obtain and learn information. One student said, "It is essential as a user to know what you are going to ask and understand the concept behind." Also, the assignment and ChatGPT helped them obtain multiple ideas and identify the main one. As a student said, "The advantage of using artificial intelligence tools is that we can get main ideas from any topic." This shows the way students obtain information, but students also reported questioning the veracity of the information that ChatGPT presented. As a student said, "The downsides were that this source is not an academic resource and therefore has no review to verify that what it says is true. The way to prevent it is that, in addition to using GPT chat, you rely on academic sources."

Learning tool: Students' self-reported answers suggested that artificial intelligence became a tool that allowed students to learn about a specific topic. It allowed students to obtain research sources that helped them in their learning process. As a student said, "For research processes, you can start from the sources provided by AI, but the literary review must be expanded." Also, ChatGPT provided students with an overview of the topic being studied in the assignment. As a student said, "Chat GPT helped me to broadly understand general project issues." Besides the overview of the topic, the provided information also promoted the investigation and understanding of the topic. "Chat GPT breaks an initial barrier that makes knowledge more accessible. It is especially useful, especially to have some information."

Table 1.1.- Summary of the Analysis of the Results Obtained

Method to obtain and interpretate information	Allow students to obtain concise information
	Allow students to synthesize information
	Is a tool that helps to understand a topic
Analytical thinking	Allows question formulation
	Is a tool that helps to identify the main idea of a topic
	Questioning the veracity of the information
Learning tool	Allow students to obtain research sources
	Provide students an overview of the topic
	Promote the investigation and understanding of the topic

Conclusion

This study has provided a deeper understanding of how students can effectively utilize generative artificial intelligence to develop skills such as critical thinking and information analysis. Although still in its early stages, the study has demonstrated the positive impact of AI in education, offering a preliminary insight into how it can contribute to the development of critical thinking by facilitating information gathering, learning new content, and forming informed conclusions. However, it is crucial to be critical and carefully analyze the information provided by ChatGPT. Overall, the preliminary findings highlight the potential of integrating generative AI into civil engineering education to enhance students' critical thinking skills. The findings suggest that AI tools can enhance students' ability to analyze, synthesize, and interpret information. Nonetheless, responsible use of AI and its combination with academic resources are essential to address challenges and maintain the integrity of the learning process. For future research, expanding the number of respondents and conducting further studies to better understand the relationship between generative AI and critical thinking in construction-related education is recommended, aiming to use it as a supportive method for students to expand their knowledge and formulate their own conclusions based on the information obtained.

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