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Supporting Generative AI Literacy: Exploring the Pedagogical Roles Students Assign ChatGPT and Impact on Course Grades

Apoyando la alfabetización en IA generativa: Explorando los roles pedagógicos que los estudiantes asignan a ChatGPT y su impacto en las calificaciones del curso

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ABSTRACT

This research examines generative AI (GenAI) use in a university course that encouraged ChatGPT for specific assignments. Using the Pedagogical Centered AI (PCAI) framework, we explore how students perceive, use, and position ChatGPT, and how usage patterns influenced performance. Students utilized ChatGPT during the latter half of the Spring 2024 semester. Comparisons were made with the first half of the course and prior iterations (2022 and 2023) without GenAI. All students in the 2024 cohort — 40 students — were invited to participate in the study. Data includes 18 student interviews from the 2024 cohort and student work from all iterations. Interviews underwent qualitative deductive thematic analysis using PCAI's predefined codes PCAI frames AI in education through six learning theories: behaviorism, cognitivism, constructivism, social constructivism, experiential learning, and communities of practice. Class materials and academic records were analyzed to assess performance quantitatively using inferential statistics. Findings reveal students predominantly view AI from a behaviorist perspective: as a tool for completing tasks. Some aligned usage with cognitive learning theory by using AI to reduce cognitive load, while others adopted social constructivist or constructivist perspectives, using AI to build understanding through feedback and exam preparation functions. Overuse of ChatGPT correlated with lower grades, though only one student acknowledged its negative impact on learning. We discuss implications for higher education and highlight how ChatGPT supports diverse teaching and learning approaches tailored to students' needs. In particular, strategies aligned with constructivism, social constructivism, and communities of practice approaches seem to enhance student learning. However, behaviorist approaches to AI use could hinder learning outcomes. Although most students were aware of the negative impact of AI overuse, they also mentioned that minimal training and explanation were provided in other classes, highlighting the need for a more comprehensive program to support AI literacy in higher education.

RESUMEN

Esta investigación examina el uso de la IA generativa (GenAI) en un curso universitario que fomentó el uso de ChatGPT para tareas de la clase específicas. Utilizando el marco de IA Centrada en lo Pedagógico (PCAI, por sus siglas en inglés), exploramos cómo los estudiantes perciben, utilizan y posicionan a ChatGPT, y cómo los patrones de uso

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influyeron en el rendimiento académico. Los estudiantes utilizaron ChatGPT durante la segunda mitad del semestre de primavera de 2024. Se realizaron comparaciones con la primera mitad del curso y con iteraciones previas (2022 y 2023) sin GenAI. Los datos incluyen 18 entrevistas con estudiantes de la cohorte de 2024 y trabajos estudiantiles de todas las iteraciones. Las entrevistas se analizaron cualitativamente mediante análisis temático deductivo utilizando los códigos predefinidos de PCAI. PCAI enmarca la IA en la educación a través de seis teorías de aprendizaje: conductismo, cognitivismo, constructivismo, constructivismo social, aprendizaje experiencial y comunidades de práctica. Los materiales de clase y los registros académicos se analizaron cuantitativamente mediante estadísticas inferenciales. Los hallazgos revelan que los estudiantes consideran la IA principalmente desde una perspective conductista: como una herramienta para completar tareas. Algunos alinearon su uso con el cognitivismo, utilizando la IA para reducir la carga cognitiva, mientras que otros adoptaron perspectivas constructivistas o constructivistas sociales, utilizando la IA para construir conocimiento mediante las funciones de retroalimentación y repaso para exámenes. El uso excesivo de ChatGPT se correlacionó con calificaciones más bajas, aunque solo un estudiante reconoció su impacto negativo en el aprendizaje. Discutimos las implicaciones para la educación superior y destacamos cómo ChatGPT apoya enfoques diversos de enseñanza y aprendizaje adaptados a las necesidades de los estudiantes. En particular, las estrategias alineadas con el constructivismo, el constructivismo social y las comunidades de práctica parecen mejorar el aprendizaje de los estudiantes. Sin embargo, los enfoques conductistas en el uso de la IA podrían obstaculizar los resultados de aprendizaje. Aunque la mayoría de los estudiantes eran conscientes del impacto negativo del uso excesivo de la IA, también mencionaron que en otras clases se proporcionó poca formación y explicación sobre su uso, lo que resalta la necesidad de un programa más integral para fomentar la alfabetización en IA en la educación superior.

KEYWORDS | PALABRAS CLAVE
ChatGPT, Generative AI, Higher Education, Pedagogical Centered AI, Students, Course Performance.
ChatGPT, IA generativa, educación superior, IA centrada en la pedagogía, desempeño académico, estudiantes.

1. Introduction

The potential of artificial intelligence (AI) to transform teaching and learning experiences is globally recognized (Cardona, Rodríguez, & Ishmael, 2023; European Commission Directorate, 2022). ChatGPT, a large language model released in November 2022, has emerged as one of the most popular Generative AIs, and researchers have extensively used this tool in teaching and learning practices (Lo, Hew, & Jong, 2024; Whalen & Mouza, 2023). However, while attention is centered on the development, capacities, and application of AI, there is still a lack of understanding of its pedagogical impact (Díaz & Nussbaum, 2024; EDUCAUSE, 2019; Rahm & Rahm-Skågeby, 2023), its usage (Crompton & Burke, 2023), and its specific role in the classroom. Furthermore, the design and implementation of AI in education lack well-founded pedagogical principles (Chiu et al., 2023; Zawacki-Richter et al., 2019), clear, strong pedagogical rationales (Gillani et al., 2023; Li & Gu, 2023; Rahm & Rahm-Skågeby, 2023), and misalignment between stakeholders can lead to inappropriate discourse regarding the role of students in the implementation of AI in education, generating AI systems that contradict existing knowledge of how students learn (Díaz & Nussbaum, 2024).

First, there is questionable discourse on the design and implementation of AI that does not represent the language of educators. For example, Ch and Saha (2019) describe their remedial tutor development target as "weak" students (students with low academic performance in mathematics). Similarly, Xia et al. (2023) reflect on the use of chatbots for second language learning, describing, "...Thus, the developers should use more data from weaker students..." (p. 15). Labeling students as weak is not accurate or constructive, even if they perform poorly in a math test. The use of this inappropriate language creates strong rejection from the education community, making it hard to achieve a positive integration and transformative aim for AI in education.

Second, the lack of pedagogical rationale and foundations guiding the use of AI in education also deviates from how AI can be effectively used. For instance, since the launch of ChatGPT at the end of 2022, several studies have focused on evaluating students' performance versus ChatGPT's performance in answering multiple-choice tests (e.g., Gilson et al., 2023; Katz et al., 2024; Wood et al., 2023). However, no clearly defined pedagogy supports comparing students against computers in multiple-choice tests (Díaz & Delgado, 2024).

Third, even though there have been strong advancements in AI capabilities, there is still minimal understanding of the role that AI plays. For instance, while Mollick and Mollick (2023) propose seven approaches that AI could take for students, there is a lack of empirical evidence on how the students perceive those roles, how they may impact student learning, and how students actually use AI. Furthermore, even though authors have called to develop AI to mediate social teaching practices (Díaz & Delgado, 2024; Díaz & Nussbaum, 2024), research still lacks evidence to support those approaches. For instance, Tai and Chen (2024) recently evaluated the use of chatbots using three settings: one student without a chatbot, another chatbot used individually, and the other chatbot used among peers. The author found higher gains in English as a Foreign Language (EFL) with those groups that used the chatbot, but there were no differences among the types of interaction used.

To address these gaps, this research studies an engineering class in a highly research-intensive U.S. university —Legal Aspects of Constructing—where the instructor of the class encouraged students to use AI, specifically ChatGPT, to complete their class homework for this course. These homework assignments consisted of heavy reading material and case studies that were spread out over the entire semester. To complete the assignments, students had to answer questions related to these texts. The instructor encouraged students to use ChatGPT to facilitate the reading process and complete the homework with AI support. Using the Pedagogical Centered AI (PCAI) model (Díaz & Nussbaum, 2024), adapted from the Human-Centered AI (HCAI) model (Shneiderman, 2020, 2022), this mixed-method research evaluates multiple student interviews as well as class homework and final class performance.

2. Research Aims

This study aims to explore how engineering students conceptualize and utilize AI to support their classwork, examining the different ways AI is used and how these correlate with academic performance. The goal is to understand the various roles AI can play in supporting student learning in higher education, and their pedagogical impact.

The research focuses on the Legal Aspects of Contracting course — a class where the instructor is part of the research team, providing full access to the course. This class is known for its heavy reading and writing workload, which makes it particularly relevant for studying AI's usefulness in reducing these burdens by improving reading efficiency and enhancing writing productivity. This creates a unique opportunity to examine AI's impact through a case study approach.

Furthermore, since the research team has access to historical class performance data from before the launch of ChatGPT, as well as data from subsequent years with progressively integrated AI tools — all under consistent course materials, equivalent assessments, and the same instructor — this setup offers a rare opportunity to analyze how different levels of AI integration may relate to average student performance over time. Specifically, this research seeks to answer the following questions:

1. How do students describe ChatGPT's role in mediating their learning outcomes for the class? And how do those roles align with the pedagogical usage in the PCAI model?
2. What are the differences (if any) in the students' class performance before and after using ChatGPT?

3. Framework: Pedagogical-Centered AI

Changing the paradigm where the capabilities of automation in AI were seen as *opposed* to human control, Shneiderman (2020, 2022) proposes a two-dimensional model to design Human-Centered AI (HCAI). This model emphasizes the equal importance of maximizing both human control and computer automation to develop safe and trustworthy systems. The focus is on developing and implementing AI technology to enhance human capacities rather than replace humans, prioritizing human users in the design process (Bingley et al., 2023; Ozmen Garibay et al., 2023; Usmani, Happonen, & Watada, 2023). HCAI is widely used to design AI tools for implementation in various disciplines, including education (Alfredo et al., 2024; Li & Gu, 2023).

Recently, based on an in-depth analysis of current research on AI in education, Díaz and Nussbaum (2024) propose an adaptation of the HCAI framework to develop and implement AI to support teaching practices, describing the result as a Pedagogical Centered AI (PCAI). First, they proposed adapting the dimension of human control to clearly distinguish between experiences with teacher control (also known as teacher-centered) and learner control (also known as learner-centered). For instance, when human control is centered on the teacher, students are seen as having a more passive role in their learning, with minimal accommodation made to adapt the material to their specific background or needs. In a student-centered AI approach, students play an active role as their needs, background, and previous experience drive the path of learning.

Secondly, they provide a further interpretation of the dimensions of computer automation in education. They describe AI systems with a high level of automation as those systems that have been developed with high pedagogical intelligence—mimicking the ideas of multiple intelligences by Gardner (2003, 2011). In addition to having systems with high autonomy, capable algorithms and technologies must be developed to allow those systems to work with minimal human intervention. Automation must also be ruled and grounded on solid pedagogical principles. For example, an online asynchronous course with minimal computer automation might mean that students follow a fixed order of content with no interaction. By adding automation to this system, content delivery could be adapted based on students' needs and backgrounds. Initially, the system can identify students' alternative conceptions, such as those related to climate change, and then automatically assign a learning path tailored for that student.

The authors discuss that although AI can be designed to be strongly controlled by humans, different pedagogical approaches in teaching and learning environments will vary depending on whether the control is applied by the student or the instructor. In particular, Díaz and Nussbaum (2024) also identified and categorized empirical research on AI in education within major theoretical learning frameworks: behaviorism (Watson, 2017), cognitivism (Bruner, 1966), constructivism (Piaget, 1973), social constructivism (Vygotsky, 1978), experiential learning (Kolb, 1984), and communities of practice (Lave & Wenger, 1991).

The authors (Díaz & Nussbaum, 2024) describe AI's role and emphasis under each pedagogical approach in the class. For instance, AI implemented under behaviorist pedagogical instruction would focus on providing consecutive exercises (stimuli) and reinforcement without accounting for student differences. In this case, the behaviorist AI would have little automation and no control by the students. Another example is AI with a more constructivist approach, designed to create different learning paths by recognizing students' prior experiences, which would have higher automation. The proposed idea is that

AI capabilities must be strongly linked to the pedagogical approach being implemented. For more detail and examples visit Díaz and Nussbaum (2024, pp. 12-14).

In this study, we operationalized the role of AI and the students' use of it in the class under the lens of PCAI. We will classify how students describe their usage and perception of AI using the six main learning theories based on the definitions provided in the PCAI framework.

4. Literature Review of the use of ChatGPT in Education

Since its launch on November 30, 2022, ChatGPT, a generative pre-trained model, has revolutionized the world, reaching approximately 100 million active users within two months of its release, making it the fastest-growing consumer application (Hu, 2023). Education has not been excluded from this trend, and numerous authors are engaging in the debate about using ChatGPT for teaching and learning purposes. For instance, there are heated discussions about its features (Chomsky, Roberts, & Watumull, 2023), concerns regarding the ethics and trustworthiness of students (Farhi et al., 2023), and its potential applications (Zhang & Tur, 2023).

ChatGPT has been utilized across multiple disciplines, educational levels, and in various ways. The proliferation of ChatGPT in educational research has led to the publication of several literature reviews (Adeshola & Adepoju, 2023; Lo, 2023). Some of these reviews focus on specific educational levels, such as higher education (e.g., Dempere et al., 2023) or K-12 (Zhang & Tur, 2023). Different types of literature reviews have been conducted, including systematic literature reviews (Montenegro-Rueda et al., 2023; Zhang & Tur, 2023), rapid reviews (Lo, 2023), and bibliometric reviews (Baber et al., 2023). Some reviews focus on specific applications, such as the use of ChatGPT for English language evaluation (Nasrullah & Al Wahyu, 2024) or its influence on student engagement (Lo et al., 2024). Some empirical studies have been conducted. For instance, in a civil engineering education setting, Uddin et al. (2024) instructed students to use ChatGPT to answer questions related to Construction Surveying and Geomatics course content. The students demonstrated knowledge gains and were able to provide more thorough, detailed, and informative written responses with the help of ChatGPT. In another study, Uddin et al. (2023) showed that ChatGPT could also be used to enhance hazard recognition levels for construction professionals. Sun et al. (2024) investigated ChatGPT-facilitated programming (CFP) practices and found that while CFP enhanced college students' programming performance, there was no statistically significant difference in learning outcomes between the CFP and self-directed programming (SDP) modes. Other studies also showed that ChatGPT can simplify complex concepts (Talha Junaid et al., 2024), enhance creativity in generating ideas (Lee & Chung, 2024), and cultivate critical thinking (van den Berg & du Plessis, 2023). Despite the variety of literature reviews, a common theme emerges there is still a lack of understanding, and more empirical research is needed to comprehend the role and pedagogical implications of ChatGPT in classrooms.

Generative AI, like ChatGPT, has high computational automation capabilities, allowing it to potentially adopt every pedagogical approach outlined in the PCAI model. Recent empirical studies, such as Kim and Rachmatullah (2025), have explored how AI can be used as a tool (aligned with behaviorist principles), as a partner (aligned with social constructivism), and as part of communities of practice to support inquiry and facilitate knowledge building in a social context.

While the authors may refer to these three types of AI usage differently, they can still be interpreted within the PCAI framework. However, no findings specifically aligned with cognitivism or constructivism were reported, which is an important gap to address.

This study examines how students conceptualize and use AI, reflecting its pedagogical role. Additionally, we will evaluate how AI usage impacts student performance both generally and by task type (e.g., individual assignments vs. group projects).

5. Methods

5.1. Research Context

This research is conducted using data from 2021 to 2024 generated from the engineering class Legal Aspects of Contracting course (CE 464/564) offered by a research-intensive mid-Atlantic American university. This course is intended to provide a practical introduction to the legal topics and issues related to the construction process. The course covers the legal theories, principles, and established rules that will likely be encountered in the construction industry as they specifically relate to contract, management, and professional issues. The

course covers legal aspects of contract documents; drawings and specifications; owner-engineer-constructor relationships and responsibilities; bids and contract performance; labor laws; governmental administrative and regulatory agencies; torts; business organizations; ethics and professionalism; analysis of current topics and issues; investigation of recent statute and case implications. It is offered as a three-credit lecture course taught twice per week and is offered to both undergraduate and graduate students. This is an ideal course for testing out AI using ChatGPT since this course has a significant amount of reading.

This course includes homework assignments, projects, and exams. In order to guide the student through the required readings, homework assignments are given in advance to help students prepare for the topics covered during the next class period. Each homework assignment consists of short answer questions from the required reading. There are 18 homework assignments throughout the semester, and each assignment must be submitted prior to the lecture. A term project is required where students working in groups assemble a portfolio of construction contract documents for a hypothetical construction project case study with numerous contractual events. Additionally, a legal case summary is required for graduate students and optional for undergraduate students who are interested in obtaining extra credit. This assignment allows students to apply classroom knowledge to real-world cases that are of particular interest.

In previous course offerings, AI was not incorporated into the class. In the second part of the spring 2024 semester, students were encouraged to use AI to complete class homework and projects, which included uploading textbook chapters and using a chatbot to answer questions pertaining to the reading assignments. Indeed, during the first part of the course (weeks 1–8), students completed homework without being introduced to ChatGPT, but in the second part of the course (week 9 to the end of the semester), they were encouraged to use ChatGPT to facilitate their homework. This is the first year we have been able to experiment with AI on this course.

Homework assignments were done without the class-sanctioned use of AI during the first half of the course, and then students were allowed to use ChatGPT to help them answer the homework questions in the second part of the course. For the case summary, students were encouraged to use the same approach to develop their case summaries.

5.2. ChatGPT in Legal Aspect of Contracting

Students were introduced to the use of the Retrieval Augmented Generation (RAG) approach to integrate construction legal knowledge into the language model (LLM). This enabled students to ask domain-specific questions, thereby enhancing their learning experience. Traditionally, enhancing a language model to understand a domain-specific topic relies on fine-tuning, which demands extensive data to train and adjust model parameters, often resulting in a less adaptable model prone to "hallucinations" when encountering unseen query data. In contrast, RAG utilizes a pre-trained LLM integrated with a retrieval system that links to external databases. A study by Ovadia et al. (2023) found that the RAG approach consistently outperformed fine-tuning in terms of injecting knowledge into LLMs.

The second author of this paper went to the class and taught students how to implement RAG using ChatGPT. Consequently, students uploaded legal class materials (in .pdf format) to ChatGPT. The material underwent several steps in the ChatGPT, including (1) parsing PDF into texts, (2) cleaning and tokenizing the text, and (3) segmenting the text into chunks using sentence segmentation or sliding window techniques. Next, ChatGPT embedding models were utilized to convert text chunks into vector representations, capturing the semantic meaning of the text. These embedding vectors were essentially stored in a virtual vector database (e.g., ChromaDB, FAISS). When a student's query is vectorized, it is compared with all vectors in the database using similarity comparison techniques, such as cosine similarity. This process indexes the most relevant vectors and maps them to the corresponding texts, which are then retrieved. These retrieved texts provide the "context" for ChatGPT to generate responses to user queries.

Students were encouraged to use ChatGPT to complete their class homework (by uploading their reading assignments) and class summary projects during the second half of the spring 2024 semester. However, using ChatGPT was not a requirement or obligation of the course.

5.3. Participants

Every spring, the Legal Aspects course is offered to senior undergraduate and graduate students. On average, the class has about 40 students. In 2024, the class consisted of 21 undergraduate and 22 graduate students.

The participant selection followed a convenience sampling method, where the course was taught and evaluated by the third author. The exploratory nature of this study aligned with this approach. All students in the 2024 course were invited to participate in the study.

The first and second authors visited the class twice to invite students to participate. Sixteen students signed the consent form. All students who signed the consent form were also invited to participate in interviews, and 12 agreed to participate.

5.4. Data

5.4.1. Qualitative

Eighteen semi-structured interviews were conducted with the students of the class: 12 in the middle of the course and six at the end of the course. The research team developed the protocol based on the PCAI framework, explicitly addressing the research questions. All interviews were conducted via Zoom by the first author, an experienced researcher with a solid background in science and engineering. The second author, a postdoctoral scholar with a background in construction and computer science and a former teaching assistant for the class, acted as the note-taker. Each interview lasted an average of 25–30 minutes. Students who participated in the interviews received a $15 gift card as compensation for their time.

To facilitate subsequent qualitative analysis, we recorded audio using Zoom. To record only audio, we requested participants turn off their cameras during the interviews, as Zoom does not allow recording only audio. To improve the quality of the transcripts, we integrated speaker diarization and automatic speech recognition (ASR) techniques, which have demonstrated outstanding performance in a previous study (Chen et al., 2025). A qualitative comparison with the default Zoom transcripts revealed that this approach consistently outperformed in terms of word and character accuracy. Consequently, transcripts produced using this enhanced method were used to conduct detailed analyses of student interviews.

5.4.2. Quantitative

Data includes the current semester grades as well as historical class grades (from 2022). The academic gradebook includes specific grades for each class's homework assignment, exam, and final case study. All activities are graded on a scale of 0-100. Homework assignments (based on readings) are evaluated by a teaching assistant using an instructor's rubric. Case studies and exams are graded by the teacher. The course has been taught by the same instructor for the last ten years; however, the teaching assistant has changed over time. The number of students enrolled in the course was 42 in 2024, 39 in 2023, and 41 in 2022. The class materials used during the years covered in this study (2021-2024) are equivalent. The instructor developed all class assignments and homework, maintaining similar difficulty levels across the years.

5.5. Data Analysis

5.5.1. Qualitative

Qualitative data from the interviews were analyzed using deductive thematic analysis (Braun & Clarke, 2006). The first author, an experienced qualitative researcher, initially developed a codebook using a priori codes (*Behavior*, *Cognitive*, *Constructivism*, *Social Constructivism*, *Communities of Practice*, *and Experiential Learning*) that are available in the literature on PCAI and were discussed in the background section of this article (sections 1, 3, and 4).

The first author shared the codebook with the research team and met with the second author to review and refine it. Minor changes were made to improve the codebook. Then, the first author, a PhD-level researcher with a solid background in technology education research and qualitative analysis, and the second author, a postdoctoral researcher with a strong background in AI and a former teaching assistant for this class, selected one interview and coded it together. They carefully discussed when and why each code should be applied. After collaboratively coding and resolving all disagreements, they updated the codebook by adding examples of when to use each code.

5.5.2. Quantitative

A statistical descriptive analysis was run on students' grades per year. A comparison among grade cohorts was performed using a *t*-test.

5.6 Reliability and Validity

To improve the reliability and validity of the qualitative data, we used semi-structured interviews. The development of the semi-structured interview was led by the first author, an experienced researcher familiar with this technique. The first author had previously developed multiple protocols to study other engineering classes offered by the same department at the same university. He built this protocol based on a previous one (Díaz et al., 2024) and refined it in consultation with the fourth author — an experienced qualitative researcher. To ensure content accuracy, the second author also reviewed the protocol. All interviews were conducted by the first author, with the second author present online to provide support, if needed.

Each coder independently coded one interview. Following the process proposed by Guest, MacQueen and Namey (2012), inter-coder agreement was calculated, achieving a 90% agreement. Disagreements were discussed and resolved, after which the coders coded the remaining interviews.

For the quantitative evaluation, all class materials were developed by the third author, who has taught this course for several years. The second author is also an expert in the discipline and was a former teaching assistant for this class during his doctoral program. Homework assignments were developed prior to the start of this research. Although minor modifications are made from semester to semester — mainly to reflect updates in legal aspects — the class readings and homework tasks remain largely unchanged. The class structure and evaluation methods (homework, tests) are consistent across semesters, with most homework prompts and rubrics [or grading procedure] staying the same.

The final exam, used in this study as an individual knowledge assessment, was also developed by the third author. Drawing from his extensive experience, he designed the final exam to maintain consistent difficulty levels across years. While slight modifications to the questions occur, the overall level of difficulty remains the same. The third author also created the final exam rubric and graded all exams. His extensive background and expertise in teaching this class ensure a consistent and reliable evaluation process, which has been maintained across previous years.

5.7. Analytical Strategy

RQ1: How do students describe ChatGPT's role in mediating their learning outcomes for the class? And how do those roles align with the pedagogical usage in the PCAI model?

To address RQ1, we conducted a qualitative deductive thematic analysis of the students' interviews. Using the PCAI lens, we analyzed the ways students described their use of ChatGPT under the main pedagogical approaches outlined in the mode, and their frequencies. Additionally, we examined variations in their usage based on task type. For the mid-course interviews, we focused on how students utilized ChatGPT for individual class assignments, as encouraged by the instructor. For the end-of-course interviews, students were specifically asked about their experiences with the final class project, which was designed to be completed collaboratively within small teams.

RQ2: What are the differences (if any) in the students' class performance before and after using ChatGPT?

Considering that the class materials were reused each year and that the class work, case studies, and exams were similar among the cohorts of the course, we compared the 2024 cohort—the first year students used AI as a pedagogical tool—with the previous years (2021, 2022, and 2023) to evaluate differences in their overall class performance. Additionally, the final exam of the course is a closed-book, individually completed exam with similar difficulty across the years and revised by the same instructor. This procedure ensures that AI was not used during the final exam. We used this as a measurement to evaluate the students' learning outcomes.

6. Results

6.1. RQ1 How do Students Describe ChatGPT's Role in Mediating their Learning Outcomes for the Class? And how do those Roles Align with the Pedagogical Usage in the PCAI Model?

The analysis of student interviews revealed various ways in which students used ChatGPT for their class assignments. In total, a code was applied 137 times to students' interview transcripts. Table 1 presents the frequencies of each coded instance associated with a learning theory.

Table 1: Coded Frequencies Applied.		
Learning Theory	Number of Instances Used	% Frequency
Behaviorism	62	45%
Cognitivism	33	24%
Constructivism	18	13%
Communities of Practice	8	6%
Social Constructivism	15	11%
Experiential learning	1	1%

The most common use was simply inputting their homework questions directly into ChatGPT and using the AI-generated responses to complete their assignments, which was classified as a behaviorist approach. For instance, one student described their experience:

> "I just didn't have time to complete the homework. And so, you know, I took the entire homework and copied it into ChatGPT, and it spits out all the answers." (Student #3)

This aligns with behaviorists' emphasis of 'speedy, correct responses' to stimuli. Other students mentioned using a similar approach but with additional steps to verify or enhance the AI-generated responses. For example, one student explained:

> "When you guys came, like, I didn't trust it that much, so I just double-checked the information more. And then, when I realized that it was amazing, I just copied and pasted the whole chapter, asked the question, and then modified the content." (Student #4)

Both cases were classified as behaviorist-aligned usage with the AI as a tool. Even though the second student checked the results, they only saw the AI as a tool to complete tasks.

Interestingly, some students used ChatGPT not just to complete their assignments but also to compare their own work with the AI's output, which is described differently from the previous behavior learning usage approach, with now alignment better with social constructivism. One student described this approach:

> "For this class, actually, I kind of use it. But basically, first, I went through the syllabus, which I had to understand and learn. Then I come up with my solutions. And then I ask ChatGPT to give me the solution it came up with. And then I match both answers and prefer the one which is good." (Student #12, mid-course)

This explanation mirrors collaborative work, where individuals complete tasks independently and then compare results to select the best one. In this case, the student used ChatGPT as a "second person" for cross-checking, consistent with social constructivism.

Another student used ChatGPT to complete assignments and then cross-examined the AI's output with their peers:

> "I do some assignments. I usually talk to a few of my friends over here who are in the same class, and we talk with each other, and we like cross-examine our assignments and papers. Sometimes, I realize, okay, that answer is wrong, and this is not what the question asked. The professor wanted something different." (Student #11)

This type of usage was described as social constructivism, as AI was a tool that facilitated collaboration and comparison with peers.

In contrast to students who copied and pasted entire assignments, some students limited their use of ChatGPT to specific assistance with assignments or concepts they found unclear. For instance, one student said:

> "I've used it [ChatGPT] more when I get stuck on maybe a concept in the book or a specific question. At that point, I will take a chapter out of the textbook, upload it to the ChatGPT sidebar thing that the professor showed us, and then try to use that to answer my question or clarify something I'm confused about." (Student #5)

In such cases, the usage was conceptualized as a cognitive tool- aligning it with cognitive learning theory. Indeed, it helped students clarify concepts and assisted them when they were "stuck" on class material.

Students also used ChatGPT to design study plans for exams. For example, one student mentioned:

> "Even for the exam, right? I would almost ask ChatGPT, 'What type of questions do I need to ask you to make the best study guide?'" (Student #1)

This student further described how ChatGPT could create a study guide:

> "Then, you know, learn how to ask it to pull out the right stuff to maybe create a two-page study guide, versus me trying to look through 80 pages of readings." (Student #1)

This usage, where ChatGPT is employed to summarize and condense information, was echoed by other students:

> "I used it a little bit for compiling stuff for the final exam. I was uploading files to ChatGPT and asking it to pull the most important topics or summarize these different topics." (Student #5)

> "It's a very mature tool that can definitely help in career ways, like if you have to go through a lot of case studies and case papers, it can summarize them quite well." (Student #12)

Given the course's heavy reading load, it was expected that students would frequently use ChatGPT to reduce the cognitive effort required for studying which is align with the perspective of cognitive learning theory.

To further analyze how students used ChatGPT in their learning process, we classified their behaviors according to the pedagogical concepts in the PCAI model, focusing on behaviorism, constructivism, experiential learning, social constructivism, cognitive learning, and community of practice.

Behaviorism emerged as the most common pedagogical framework. Students predominantly used ChatGPT as a tool that responds to a specific stimulus (input) by completing the task (output). This behaviorist usage was highlighted 62 times across the data. For example, students mentioned:

> "So it's like, OK, ChatGPT, give me the average rate of liability insurance. That's it." (Student #2, mid-course)

> "If there's a question on the homework that I cannot locate within the slides, I will use ChatGPT to answer said question. I've also used it for other purposes, like helping me answer questions and more easily find answers." (Student #3, mid-course)

While ChatGPT was widely used as a behaviorist tool, students were also aware of its limitations, especially for more specialized content. One student noted:

> "But if there was any heavier concept for the engineering class or something, I wouldn't use ChatGPT. I mostly limit ChatGPT to very miscellaneous things." (Student #2, mid-course)

Cognitivism was the second most common framework identified in the data. Students described using ChatGPT as a cognitive tool, particularly for summarizing large amounts of reading material:

> "I used it as kind of like a more of a summary tool, really, for the big, large documents that we had." (Student #8)

By mid-course, all students shared how ChatGPT effectively reduced cognitive load, particularly in managing the course's heavy reading requirements. This usage aligns with our expectations, given the course's demand for extensive reading.

All students acknowledged the limitations of ChatGPT, such as hallucinations or inaccurate responses. However, they also developed their own strategies to identify and address these issues. For instance, Student #7 described asking ChatGPT to provide specific text references to help locate relevant material:

> "I also tell it to okay, give me a paragraph about where you found this, the answer to the questions, you know, so that way I'm only reading. Like what the professor wants me to read, you know, instead of he says, okay, read chapter eight, but there are only 10 questions. Okay. We don't need to read the whole chapter, obviously, but he's not going to tell us, you know, which paragraphs we need to read and find the answers, but you know, the AI will." (Student #7)

Student #7 highlighted the use of ChatGPT to reduce reading time and manage the workload required

to complete their readings. This approach aligns with a cognitivist learning theory, as it involves optimizing cognitive effort. However, the student also implemented strategies to ensure they still engaged directly with the text rather than relying entirely on AI for interpretation. Similarly, Student #5 also acknowledged the issue of hallucinations and emphasized the importance of double-checking the material:

> I would ask it a question. I'd get a response. And then I would check it in the book just to make sure that like it wasn't making stuff up. And, like I think somebody said "hallucinating". And it was pretty bad, probably like 20 percent of the time, it hallucinated and it would make up some historical event. And so I was like, OK, I'm not going to I'm not going to mess with this. This is too unreliable.. (Students #5)

It is also relevant to note that this approach helps develop students' metacognition by encouraging them to critically analyze how AI does not generate material directly from sources or pre-existing schemas. Instead, it creates content and outputs that cannot be traced back to previous sources. In these scenarios, the learning theory that students most commonly referenced aligns with constructivism.

An interesting case emerged with Student #10, where the weaknesses of ChatGPT—its errors or hallucinations—actually helped foster critical thinking in the class. He explained:

> One thing it's, too, is that when I do ask for an answer from it, I have to look back over and see what response it gave me. Cause sometimes the information from Chat Gpt is not accurate. I've noticed that it's not always. It doesn't always give you back what you asked it for. And so I would say, in a way, it's almost helped with critical thinking, because it's taught me how to go back through and check and make sure that it's actually what I need. And it answer the question in the way that I needed to? And if not, how can I change that prompt, or how can I give it more information? (Students #10)

In this sense, students' awareness of AI's limitations helped them develop critical thinking skills when formulating questions and evaluating the accuracy of responses. This aligns with Piaget's constructivist learning perspective. Although Student #10 was the only one to explicitly describe this, it represents a promising approach to understanding how students engage with AI in their learning process.

There was a total of eighteen homework assignments for the course. Starting with homework 12, students began using ChatGPT and RAG to assist with their work. Homework was graded primarily using a binary system: 100 points for a submission and 0 points for a missing submission. Deductions from the 100 points were made based on the extent to which key solutions were missing. The average grades for homework, final exams, and projects are shown in Table 2.

Table 2: Class Performance for 2024, 2023, and 2022.

Average Grade	2024	2023	2022
HW12	93.76	92.05	95.10
HW13	97.33	94.82	94.90
HW14	98.00	97.26	94.98
HW15	93.93	92.13	97.34
HW17	92.86	94.72	97.29
HW18	97.02	94.87	97.56
Final	71.62	76.50	82.51
Project	93.95	92.82	97.34

For this study, *t*-tests were conducted to compare the performance between the 2024 and 2022 cohorts, as well as between the 2024 and 2022 cohorts. Additionally, *t*-tests were performed on the results of the final exam and final project. The outcomes of these analyses are shown in Table 3.

The analysis showed no significant differences in homework performance between the 2024 cohort and previous years, as most p-values were greater than 0.05. This suggests that the introduction of ChatGPT did not lead to an overall improvement in homework grades, despite a considerable reduction in time. However, a significant difference was found in the final exam scores when comparing 2024 with 2022, with a *t*-statistic of -3.185, indicating a decline in exam performance after ChatGPT was introduced. Similarly, the final project results showed a significant difference, with negative *t*-statistic, pointing to a decrease in performance. Differences between 2023 and 2024 did not reach statistical significance.

Table 3: Comparison 2024'Class Performance with Previous Years.				
Activity	t-statistic	p-value	t-statistic	p-value
	2024 vs 2022		2024 vs 2023	
HW12	-0.294	0.769	0.306	-0.294
HW13	0.587	0.559	0.592	0.587
HW14	0.865	0.390	0.261	0.865
HW15	-0.817	0.416	0.341	-0.817
HW16	0.421	0.675	0.826	0.421
HW17	-0.938	0.351	-0.344	-0.938
HW18	-0.156	0.877	0.503	-0.156
Final	-3.185	0.002	-1.412	-3.185
Project	-5.728	0.000	0.351	-5.728

7. Discussion

To unlock the potential of AI to support teaching and learning practices, several challenges remain: the evolving discourse around AI development, the pedagogical gaps and rationale for its use (Chiu et al., 2023; Li & Gu, 2023), and underdeveloped understanding of its role in supporting students' learning (Díaz & Delgado, 2024). Indeed, several policy documents call for research aimed at understanding how AI can be used to support teaching and learning practices (Cardona et al., 2023; European Commission Directorate, 2022).

As an answer to this need, in this study we explored how students perceived and used ChatGPT in a graduate-level class. In the context of legal aspects in construction, we employed an exploratory case study, conducting multiple interviews with students, analyzing student performance, and reflecting deeply on the class instructors' perspectives to understand how engineering students conceptualize and use ChatGPT in the class. In the analysis, we operationalized students' use by analyzing how their usage aligns with pedagogical learning theories through the lens of PCAI (Díaz & Nussbaum, 2024). This conceptual framework, previously developed by us to understand how different pedagogical approaches are operationalized in the era of AI, highlights the critical role of centering the analysis on pedagogy.

Our research found that students' use of Generative AI, specifically ChatGPT, primarily focused on behaviorist and cognitivist approaches. In this sense, students used AI to help them by inputting all the information to receive an output without or with minimal analysis of the outputs. They played a passive role in the process and were only responsible for providing a stimulus or input to the AI. Additionally, following cognitivist approaches, students asked AI to help them reduce the time needed to fully read or study class materials. They used AI to process large texts or information so they could focus on studying the smaller, processed text. For instance, to complete the reading homework, students uploaded the full text assigned for the reading and requested the AI to create a brief summary or highlight the sections of the text that were relevant for the purpose of the homework. The prevalence of these approaches are not surprising. Traditional instruction as is featured in this class tends to follow behaviorist principles, with teacher-centered activities and students as recipients of information. The heavy reading loads naturally spurred student efforts to summarize or otherwise reduce cognitive load. In both cases, the genAI is conceptualized as a tool. Díaz and Delgado (2024) noted that most research, and even ChatGPT's own description of its role, place it as a tool rather than collaborator or participant.

In addition to behaviorist and cognitivist approaches, other interesting cases emerged where some students described using AI in ways aligned with constructivism and social constructivism. In those cases, operationalized AI to improve their own *intellectual* work of constructing their understanding. In the social constructivist approach, students used AI as an element to facilitate interaction with their peers. For instance, they used AI to revise their work before sharing it and to compare and provide feedback based on the work of other teammates, consistent with recent calls to conceptualize AI as a potential full member of communities of practice (Díaz & Delgado, 2024). Students also used genAI in *individual* efforts to clarify, make sense of, and critically evaluate information, consistent with constructivism.

Finally, although usage aligned with communities of practice and constructivism was less common than behaviorist- or cognitivist-aligned approaches, it led to higher student performance in the class and reduced dependence on AI.

Our findings also align with other recent empirical studies, for example, Kim and Rachmatullah (2025), who identified three types of AI use in the field of science education: AI as a digital tool, AI as a partner for training and testing practices, and AI as a tool to compare with the field of science to generate knowledge and intellectual outcomes.

Among students who used AI as a cognitive tool, it was noteworthy that many independently developed security protocols to ensure the accuracy of AI-generated content. For instance, one student mentioned that after asking ChatGPT to provide an answer, they also requested it to highlight the text's source. This approach allowed the student to identify hallucinations and improve the reliability of ChatGPT's outputs.

Our exploratory research found that generative AI, like ChatGPT, can adapt to students' needs and preferences. It can evolve from a simple task-completion tool to a more sophisticated support system that enhances learning outcomes.

It is important to note that although students were well aware of AI's limitations, their awareness stemmed from personal experience rather than instruction or formal guidance on the risks involved. Moreover, students' strategies to mitigate these risks—such as asking ChatGPT to identify paragraphs where specific information originated to counteract hallucinations—were entirely self-initiated.

Considering that these were senior and graduate students, this raises concerns about the lack of AI literacy and highlights the importance of teaching students how to use AI effectively while understanding its risks. Urgent actions are needed to address these gaps in higher education and to provide students with formal training in AI literacy and critical evaluation skills.

7. Limitations

Although we, as researchers, made our best efforts, we acknowledge that our study has limitations. First, this is an exploratory study conducted in a single class at one university. Our focus was not on generalizing the results but on understanding their applicability. However, the transferability of these findings to other contexts may vary depending on the course design and the specific learning environment. Secondly, only half of the students agreed to participate in the research. Despite multiple invitations extended to the entire class, we were unable to involve all students. As a result, the interviews may not fully represent the perspectives of the entire class.

8. Conclusions

We found that while ChatGPT has advanced capacities, its ultimate pedagogical usage comes from students' perception and the role they ascribe to the AI. ChatGPT can adapt to students' specific approaches, transitioning from being a tool for providing information and completing tasks and activities, to reducing cognitive load, to becoming a partner that provides feedback in a dyad or larger group, or can even act as a more experienced guide to their learning. From the teaching standpoint, this means we must design experiences that account for nuanced differences and can adapt to the varied uses students might require, depending on their prior knowledge and experience using AI

An important aspect is the potential issues and critiques of ChatGPT related to hallucination (Alkaissi & McFarlane, 2023; Ji et al., 2023) and the lack of trustworthiness of its outputs. These issues offer opportunities for students to learn. As one student described, being aware of these limitations helped them develop critical thinking, as they had to carefully analyze the responses and decide whether the information was appropriate. Future experiences could leverage this aspect to turn the disadvantages of ChatGPT into opportunities for developing critical and complex skills, such as critical thinking (Hsu et al., 2022).

Finally, while some students may rely heavily on ChatGPT, negatively impacting their learning and performance in class, one student offered an interesting perspective. In courses like the one we studied, which are heavy on reading and require students to study several materials per week, the retention of that material becomes questionable. As one student mentioned, "I completed the assignment, closed the computer, and forgot everything." However, when they used ChatGPT to provide summaries and key points from the text, they could read these shorter summaries and retain the information much longer. This raises questions about whether heavy reading and memorization-focused courses need to change and how AI could assist from the students' perspective.

Indeed, the discussion about the use of AI and other technologies in our classes should focus on the pedagogical benefits they bring compared to traditional or normal practices that teachers currently use (Díaz & Nussbaum, 2024). This approach offers a fairer comparison, rather than comparing AI to an idealized case of teaching and learning practices without generative AI.

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