A PBL-based Mini Course Module for Teaching Computer Science Students to Utilize Generative AI for Enhanced Learning

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***Abstract*—This research-to-practice paper introduces a mini-course module designed to teach computer science students how to interact more efficiently with Generative AI (GAI). The rapid rise of GAI is transforming education by providing students with easy access to knowledge and answers to their questions, acting as a personal tutor. Particularly in the field of computer science, where GAI can easily generate code based on specific requirements, many instructors struggle to prevent students from using tools like ChatGPT for completing assigned programming assignments and homeworks. However, we argue that 1) the use of GAI is inevitable, necessitating a redesign of courses so that students cannot merely rely on GAI without actual learning; and 2) students' learning can be enhanced if they learn to use GAI more effectively. In this paper, we demonstrate how we integrate Project-Based Learning to design the course module in a concise yet effective manner, which not only facilitates students' learning of GAI but also enriches their learning in relation to the host course where this mini-course module is embedded.**

In particular, the goal of this module is to teach CS students: 1) the basic principles and workflow of GAI; 2) Prompt Engineering: how to craft questions to interact more effectively with GAI; and 3) Extending GAI: how to create interactive tools by training customized GAI models. Designed to be completed within two weeks, the mini-course module can easily be incorporated into host courses. This mini-course module was integrated into a graduate-level Artificial Intelligence course with 42 students in Winter 2024. To assess the module's impact on student learning and engagement, we conducted pre- and post-course surveys as well as student interviews. The results from the surveys and interviews highlighted key areas for improving the design of educational modules to better teach essential GAI skills. These insights focused on enhancing student engagement and learning efficiency within a concise time frame.

***Index Terms*—Generative AI, Course Module Design, Project Based Learning(PBL),**

I. Introduction

Generative Artificial Intelligence (GAI) represents a cutting-edge field within artificial intelligence that focuses on developing algorithms capable of producing content that mirrors human-like outputs, such as text, images, audio and video [1], [2]. One of the most promising and widely popular applications using GAI today is ChatGPT [3], a GAI-based large language model (LLM) developed by OpenAI [3], which has gained global recognition for its ability to handle complex language tasks and generate responses in an interactive conversational way. The recent advent of ChatGPT with its fast growing user base of approximately 180.5 billion [4] and free version offerings, has made it easily accessible [5], thus introducing the domain of GAI to a large number of general audience. Additionally, it has spurred growing interest in both research and industry, driving a wide range of applications across multiple fields. [6].

Among the diverse domains impacted by GAI, one that truly stands out is its role in transforming the traditional educational practices and learning sciences, i.e., the way people learn. For example, ChatGPT can act as a personal tutor for students, offering easy access to information, answering questions, and even generating code based on specific requirements [7]. Additionally, ChatGPT can foster independent learning by allowing students to explore topics at their own pace. With its ability to answer a wide range of questions, students can use it to delve deeper into subjects that interest them, reinforcing classroom learning and promoting curiosity [8]. Numerous educational institutions are investigating how ChatGPT can enhance learning environments. Furthermore, universities have been creating their own GPT-based tools to assist students with coursework using no-code platforms, which facilitate student engagement and learning without requiring programming skills.

However, the growing popularity of these tools has also raised concerns about their possible impact on students' learning and educational achievements. Some educational institutions have even started taking measures to prohibit the use of certain AI platforms to maintain conventional teaching methods and skills [9]. One of the major reasons behind restricting the usage of ChatGPT by educational institutions tends to be concerns related to direct copy-pasting, which may decrease student engagement and diminish critical thinking skills. Educators face challenges in preventing the use of ChatGPT for completing assignments, coding tasks, and homework, which could lead to issues like plagiarism, over-reliance on technology, misinformation, and ethical problems [5]. Despite efforts to limit its usage in the educational domain, its widespread availability and easy access make it challenging to control its adoption among students [10].

Based on our experience with teaching ChatGPT in vari-

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ous courses and observing students' learning outcomes, we strongly believe that **rather than banning ChatGPT, instructors should teach students how to effectively utilize such tools to enhance their learning experiences**. This becomes evident as the advantages offered by GAI tools in the educational domain outweigh the disadvantages, and their widespread usage is almost inevitable. Research has demonstrated that tools like ChatGPT can significantly improve student learning by acting as a personal tutor, providing immediate feedback, and generating new ideas [11], [12]. Nonetheless, there remains untapped potential due to students' limited knowledge of how to effectively engage with these tools. A study [13] found that despite students' intentions to use ChatGPT, there is a noticeable gap in their ability to engage effectively with it. Additionally, prior research indicates that enhancing students' interaction skills with large language models (LLMs) is crucial for maximizing the educational benefits, such as increased motivation and engagement [14], and enhances their learning interest [15]. Therefore, rather than restricting access to GAI tools like ChatGPT, educators should focus on equipping students with the necessary skills to leverage these tools effectively for their academic improvement. This approach underpins the motivation for this work.

In this paper, we propose integrating ChatGPT into graduate-level Artificial Intelligence classes as a mini-Project-Based Learning (PBL) course to enhance student learning outcomes. Initially, students are taught advanced GAI usages, ensuring they understand the underlying mechanisms and can interact effectively with these tools. They are then tasked with fine-tuning a ChatGPT model using data from the host course to deepen their understanding of the broader curriculum. To assess the impact of this integration, we conducted pre-course and post-course surveys as well as student interviews. These evaluations provided valuable insights into optimizing educational modules and refining our approach to effectively leverage GAI technologies in the curriculum. The feedback confirms the course's versatility and its potential to transform educational practices in the field. To summarize, this paper makes the following contributions:

1) We have designed a comprehensive mini-Project-Based Learning (PBL) GAI course module that can be integrated into any computer science (CS) host course to enhance its teaching and learning experience. Specifically, we developed three lectures that introduce the advanced usages of GAI, covering topics such as Introduction to GAI, Prompt Engineering, and Extending GAI by using ChatGPT as an example. We have made our course materials publicly available [1].
2) We conducted a pre-course survey to better understand students' requirements, which focused on: (i) identifying the need for student guidance on the effective usage of ChatGPT; (ii) determining the need for instructors to effectively integrate ChatGPT into educational settings. Additionally, we conducted a test run of the course module in a graduate-level CS course and evaluated its effectiveness and impact on learning outcomes.

[1]https://anonymous.4open.science/r/Mini-GAI-Course/

The rest of this paper is organized as follows: Section II provides an overview of the background and related works integrating ChatGPT into education and discusses our motivation for integrating a mini-Project-Based Learning (PBL) course module into host courses. Section III describes the structure and implementation of the proposed course modules. Section IV details the evaluation and observations obtained from the implementation. Finally, Section V concludes the paper.

II. Related Works and Motivation

In this section, we will first explore related works, followed by a discussion on the motivation of this paper.

1) Generative AI in Education: The integration of Generative Artificial Intelligence (GAI) into educational frameworks, particularly within computer science programs, is driven by rapid technological advancements and the expanding capabilities of these tools. Technologies such as ChatGPT have emerged as critical educational resources, providing students with immediate access to information and practical assistance in coding.

- **Integration and Impact of Generative AI in Education**: Numerous studies have explored the integration of Generative AI into educational settings, particularly focusing on its potential to enhance learning through immediate feedback and personalized tutoring [10]–[12], [16], [17]. However, there are also concerns about academic integrity and the impact on critical thinking skills. Studies highlight both the benefits, such as improved learning outcomes, and challenges, including the risk of plagiarism and issues related to content modernization [17], [18].
- **Practical Benefits of AI Tools in Programming Education**: Studies have demonstrated that the use of AI tools such as ChatGPT in programming courses significantly benefits students by enhancing their computational thinking, confidence, and motivation. These findings suggest that such tools can provide crucial support in educational settings [19], [20].
- **Faculty and Student Perceptions on the Use of Generative AI**: While generative AI tools are valued in education, their adoption by faculty remains relatively low. This low adoption rate is attributed to a lack of training and concerns about academic misconduct. Consequently, there is a significant need for educational initiatives that help faculty and students effectively use these technologies, with a focus on ethical integration and academic integrity [21]–[23].
- **Effectiveness and Challenges of AI Tools like ChatGPT in Education**: Recent research has demonstrated that tools such as ChatGPT are received positively in project-based learning settings, providing significant support in educational processes. Despite these advantages, challenges persist in maximizing the effectiveness of

these tools, particularly in enhancing interaction techniques [24], [25]. Furthermore, these studies highlight the critical need for human oversight to ensure quality and manage complex interactions effectively [26], [27].

- **Custom Tailored AI Tools for Educational Needs**: Research indicates a need for custom-tailored AI solutions in education that specifically address the diverse needs of students and enhance their engagement and learning outcomes. Innovative approaches are being explored, including the integration of generative AI tools into educational settings to tailor teaching methods and materials to individual student needs. This is particularly crucial in online classes where students may not receive much one-on-one attention [20], [28], [29].

In summary, GAI holds great potential to enhance education through personalized support and quick feedback. However, it also confronts challenges such as academic integrity, ethical issues, and the need for improved user interaction. Specialized training programs are crucial for helping teachers and students use AI tools ethically and effectively. These programs can help overcome these challenges and fully leverage the benefits of AI in educational settings.

2) Existing Programs and Courses on GenAI: There is a wide range of online courses, boot camps, and workshops available on Generative AI (GenAI), including both paid and free options. Below, we have listed some of the most popular courses on GenAI.

- **Introduction to Generative AI-Google** [30]: This microlearning course provides an introduction to Generative AI, explaining its concepts, uses, and distinctions from traditional machine learning methods. It also includes a section on using Google Tools to develop Generative AI applications.
- **Generative AI for Everyone-Deeplearning.ai** [31]: This course explores how Generative AI functions and outlines its capabilities and limitations. It features practical exercises where participants learn to use generative AI in their daily tasks. Additionally, the course provides guidance on effective prompt engineering and delves into more advanced applications of AI beyond simple prompting.
- **Applied Generative AI Training-Prude University** [32]: This is a four-month course focused on Applied Generative AI. It explores key areas such as prompt engineering, large language models (LLMs), attention mechanisms, LLM application development, and LLM fine-tuning.

3) Motivation and Requirements: The exploration of related works has enhanced our understanding of the current offerings of GenAI and its benefits for integration into the teaching and learning process, while also identifying its challenges and requirements. A major challenge is the tendency of students to blindly trust and overly rely on the responses provided by such tools, which can adversely affect their critical thinking and learning processes. Additionally, the rapid but early-stage growth of this domain has not been fully integrated into university-level course curricula, worsening the situation and leaving educational institutions with no choice but to restrict its use in educational settings.

To bridge this gap, we argue that there is an immediate need for a course design that can be seamlessly integrated into any university-level courses. Such a course would enable students to use GenAI tools correctly and effectively, thereby enhancing their learning experiences. Currently, an independent university-level GenAI course is not available, and even if it were, it might delve too deeply into the technical workings of the tools, thus failing to meet the primary objective of teaching students the practical and effective use of GenAI. Therefore, the need for a completely novel course design that meets these criteria serves as the major motivation for this paper.

To address the need for an immediate course, we have designed our course as a mini-GenAI course that can satisfy the following requirements:

1) **General Requirements:** The mini- course should provide general knowledge on the correct usage of GAI. Specifically, for computer science students, it is expected that they not only learn how to interact more effectively with existing GAI tools but also how to program with GAI and systematically utilize it for further customization, if required.
2) **Host Course-specific Requirements:** As we integrate this mini-course into any host course, students should be able to apply the GAI concepts to enhance their understanding of related topics within the host course. For this purpose, we select challenging topics from the host course and use them as demonstration examples, in hands-on labs, and in mini-projects. This approach shows students how GenAI can be applied to gain a better understanding of such concepts.

III. Course Design

The course is organized into lectures, hands-on labs, and a mini-project, where students learn the fundamentals of Generative AI (GAI), including prompt engineering and advanced GAI customization techniques such as Fine-tuning and Retrieval Augmented Generation (RAG).

A. Design

Our mini-GAI course equips students with both theoretical understanding and practical experience in Generative Artificial Intelligence (GAI) over a two-week period, making it an ideal supplement for any host computer science course. The curriculum is divided into three key modules: lectures, hands-on labs, and mini-projects.

1) **Lectures**: In the lectures, students explore the essentials of GAI, covering both foundational concepts and applications. They learn how to enhance AI interactions through effective prompt engineering techniques. The course concludes with advanced sessions on customizing GAI tools using OpenAI's fine-tuning process and Retrieval Augmented Generation (RAG).

2) **Hands-On Labs**: During these lab sessions, students actively engage in hands-on exercises that reinforce the prompt engineering and GAI customization techniques introduced in the lectures. These practical exercises are designed to deepen students' understanding of the course material and enable them to apply theoretical concepts to real-world scenarios.
3) **Mini-Project**: The mini-project involves students fine-tuning a GAI model using data relevant to specific concepts from the host course. This project helps them deepen their understanding and integrate their learning with the broader curriculum of the host course.

Lecture	Total Time (hrs)	Topic	Total Slides	Instructor Time (hrs)	Lab Time (hrs)
1	1.5	Introduction to GAI	12	1.45	0.75
		Prompt Engineering	41		
	Break (15 mins)				
	1	Fine - Tuning	6		
		Hands-On Lab			
2	0.75	RAG	8	0.75	1.45
	Break (15 mins)				
	1.45	Hands-On Lab			

Fig. 1: Mini-GAI PBL Course Structure

The structure of the course is given in the table 1.

1) **Week 1**: The first week of the course introduces the fundamentals of Generative AI and Prompt Engineering through lectures, complemented by hands-on labs that allow students to put these concepts into practice. The exploration of Generative AI continues with a focus on customizing large language models. This segment includes a lecture on OpenAI's fine-tuning process and a comprehensive demonstration using specific examples from the host course to illustrate the techniques.
2) **Week 2**: In the second week, the course progresses to more advanced customization techniques with a lecture on Retrieval Augmented Generation (RAG), accompanied by hands-on labs focused on this technology. The course concludes with a mini-project where students apply the advanced concepts they have learned to develop a Generative AI tool relevant to the host course.

B. Implementation

Our mini-GAI course is meticulously designed to deepen students' understanding of Generative Artificial Intelligence (GAI) over a concise two-week period. The course includes the following lectures:

1) **Lectures**
   a) **Foundational Knowledge of GAI**:
   This initial module introduces students to the fundamental principles and diverse applications of artificial intelligence. It focuses on explaining how AI integrates into various real-world scenarios, including facial recognition technologies, personalized content creation in social media, and advanced search engine functionalities.
   This lecture delves into AI sub-fields like Machine Learning and Deep Learning, emphasizing the differences between discriminative and generative models. It explores Generative AI, demonstrating how these models process various inputs textual, visual, and auditory to autonomously generate novel content. The aim is to expand students' understanding of AI's innovative capabilities and its transformative potential across sectors.
   Finally, we include a session on large language models (LLMs), which represent the cutting edge in natural language processing. This session covers the architectural design, pre-training processes, and specific applications of LLMs, emphasizing their ability to produce text that closely mimics human writing styles. Overall, this introductory lecture aims to build a strong foundational knowledge while also delving into specialized areas of AI, equipping students with the understanding and skills needed to navigate and contribute to the field of artificial intelligence.
   b) **Prompt Engineering**:
   Our primary objective in introducing prompt engineering to students through lectures is to teach them how to effectively ask questions of Generative AI (GAI) systems. In particular, we focus on using ChatGPT as an example throughout the course. This skill is crucial for maximizing AI benefits, whether for assignments, creative ideas, or complex problems. By effectively crafting their questions, students can guide ChatGPT to provide the most accurate and useful answers. Prompt engineering involves creating and refining prompts, understanding how AI language models function, and asking the right questions to elicit the most useful responses [33], [34].
   In our lecture on prompt engineering, we covered a range of essential topics and provided example usages to foster a basic understanding for students. We began by defining what prompt engineering is and why it is increasingly crucial in today's AI-driven world. This initial discussion helped students understand the importance of communicating effectively with AI systems like ChatGPT, highlighting the role of prompt engineering in enhancing the efficiency and accuracy of AI responses. Subsequently, we discussed various types of prompts, their roles, and patterns, providing examples for each. Students learned how the structure and phrasing of prompts can significantly influence the response. We explored strategies for creating effective prompts, emphasizing the importance of clarity, specificity, and context in formulating questions that lead to meaningful and useful AI interactions.

c) **Extending GAI**:
LLMs like ChatGPT are developed with vast amounts of textual data and can sometimes interpret queries in unexpected ways or provide generalized responses that do not align directly with the specific intent of the question. This misalignment can make it challenging to achieve the desired output from such models. These challenges can be addressed by employing customization techniques such as Fine-tuning and Retrieval Augmented Generation (RAG), which allow for the tailoring of LLMs like ChatGPT to meet specific needs and purposes.
In this lecture, we explored the technical aspects of fine-tuning, including the selection of appropriate data, setting of training parameters, and prevention of model over-fitting. Students were exposed to tools and frameworks that facilitate fine-tuning with OpenAI, and we demonstrated the entire process using an example from the host course. This example showed how to customize ChatGPT to simulate the output of various clustering algorithms, providing a clear and understandable method for students to learn about such course-specific clustering algorithms.
Another customization technique discussed was the Retrieval-Augmented Generation (RAG) module, which enhances pre-trained language models by integrating them with information retrieval systems. This integration allows for more accurate and contextually relevant responses [35]. The lecture covered the architecture of RAG, including its Vector Embedding Architecture, and provided practical demonstrations of its implementation. It also detailed the technical requirements and resources needed, such as Python, OpenAI, and specific libraries, offering a comprehensive understanding of how RAG operates and its applications across various fields. Students learned how RAG enhances the capabilities of ChatGPT, making it particularly useful for tasks requiring up-to-date information or domain-specific knowledge.

2) **Hands-On Labs**: Each lecture in the course was designed to be followed by hands-on labs, providing students with practical implementation of the topics they learned during the lectures. After completing the hands-on labs, students were asked to submit their feedback via Canvas.
a) **Week 1**: In the first week, our course covered sessions on prompt engineering and fine-tuning. For the prompt engineering hands-on lab, we provided students with a variety of story themes. Each student selected one theme and crafted a unique story using the prompt engineering techniques discussed during the lectures.
For the fine-tuning hands-on lab, students were required to choose an appropriate dataset from platforms like Kaggle [2] or Hugging Face [3] and were asked to convert the raw dataset into the JSONL format required for fine-tuning by applying the methods they learned during the lectures.
b) **Week 2**:
In the Retrieval-Augmented Generation (RAG) section of our course, we focused on two practical exercises in Google Colab [4] to explore the applications of RAG techniques:
First Exercise: Students had the flexibility to choose their own data for tasks such as text summarization, question-and-answer interactions, and information retrieval using ChatGPT. They were expected to upload their selected data, convert it into a vector database, and execute these tasks on their own.
Second Exercise: This exercise involved integrating ChatGPT with GitHub, where students used it for debugging, code validation, and code completion tasks. They were expected to connect their own GitHub repositories and perform these tasks.
These activities showcased how Retrieval-Augmented Generation (RAG) can enhance large language models, enabling them to effectively interact with external data sources and meet specific requirements and user needs.

3) **Mini-Project**: After the lectures and hands-on labs, we require students to initiate a mini-project that they propose themselves. Following project-based learning guidelines, students are asked to identify a problem related to the topics taught in the host course and apply their knowledge of Generative AI (GAI) to design and develop a solution. While we provide some potential project ideas as examples, we encourage students to think creatively about their own problems to solve.
Defining the constraints for choosing projects is crucial, as we aim to use the mini-project not only to foster students' skills in GAI but also to deepen their understanding of the host course content. To this end, we define two different directions for students to pursue: 1) developing tools or applications that apply the knowledge taught in the host course; and 2) creating tools or applications designed to help other students learn the content of the host course.
Below we provide two courses as examples.
- In the "Introduction to AI" course, students may relate their projects to the application of AI, such as developing a recommendation system or a classification application, or to fulfilling potential knowledge gaps of beginners to AI, like explaining the differences in various clustering algorithms by examples.
- In the "Computer Networks" course, students may develop tools for networking, such as calculating the routing tables based on given network typologies.

[2]https://www.kaggle.com/
[3]https://huggingface.co/
[4]https://colab.research.google.com/

To help other students, they may collect statements related to computer networks from online forums, give their own judgments on whether the statements are correct, and use the collected data to build a tool for generating quizzes.

In particular, when developing tools/applications to help other students learn the knowledge of the host course, students are asked to follow the below principles:

1) Students are encouraged to use ChatGPT and ask questions related to the topics they have learned in the host course.
2) Students should validate ChatGPT's responses by comparing them with reliable sources such as books, videos, and articles. This enhances their learning by ensuring they do not solely depend on ChatGPT but also verify the information provided.
3) If students find ChatGPT's responses incorrect, unrelated, or unclear, they are encouraged to improve them using customization techniques like fine-tuning and RAG learned in lectures and labs.
4) Students should collect and pre-process the data sources that were used to validate ChatGPT's responses or that aided in understanding the host course topics from Step 2. This processed data can then serve as the foundation for the customized model.
5) Students who developed the customized model then prompt it with the same query as before and check if the customized model can provide better responses than they expected.
6) Finally, to further evaluate the developed model, other students in the class are asked to use this customized model to learn a specific host course topic and provide their feedback in terms of peer reviews, based on which the projects are graded/evaluated.

IV. Evaluation

To evaluate the effectiveness of our mini-GAI course, we analyzed student feedback using two distinct approaches: quantitative and qualitative

A. Quantitative Approach

We conducted pre-course and post-course surveys to quantitatively analyze the results before and after the course.

1) **Questionnaire Design and Participants**: To assess students' understanding before and after the mini-GAI course, we developed targeted pre-course and post-course survey questionnaires. Detailed in Table I, these questionnaires were designed to compare changes in student knowledge and understanding before and after the course. An additional question in the post-course survey specifically addressed the effectiveness of the Project-Based Learning (PBL) methodology used in the course. Initially, 36 students completed the pre-course survey, and this number increased to 42 students who responded to the post-course survey.
2) **Results**: The pre-course versus post-course survey results, as shown in Fig. 2, clearly demonstrate the effectiveness of the mini-GAI course in enhancing students' understanding and skills in key areas of generative AI and large language models (LLMs) like ChatGPT.

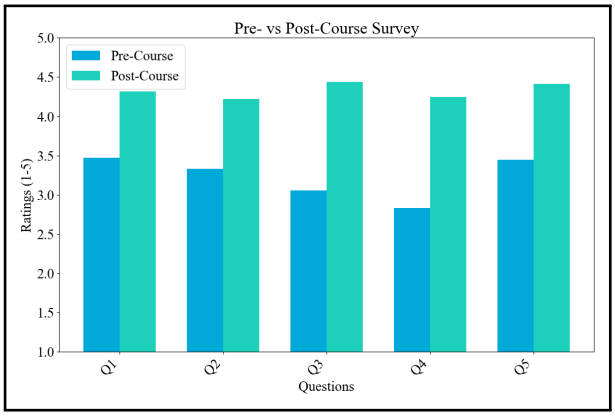

Fig. 2: Average Student Ratings of Pre- vs Post-Course Survey

- **Understanding of GAI Concepts (Q1)**: Before the course, students had a moderate grasp of GAI concepts, with an average rating of 3.8. After completing the course, their understanding improved notably, with the average rating rising to 4.4.
- **Familiarity with LLMs (Q2)**: Initially, students had a moderate familiarity with large language models like ChatGPT and Google Gemini, with an average rating of 3.6. After the course, this rating jumped to 4.7, showing a significant increase in their knowledge and comfort with these technologies.
- **Prompt Engineering (Q3)**: This area saw the largest improvement. Starting with an average rating of 3.3, it surged to 4.9 after the course, indicating that the course was extremely effective in boosting skills in prompt engineering.
- **Hands-on LLM Experience (Q4)**: Students began with a lower average rating of 2.9 in this area, which increased to 4.5 after the course. This significant rise suggests they gained practical experience and are now better prepared to apply these skills in real-world settings.
- **Technical Background (Q5)**: Prior to the course, participants rated their technical background quite high at 4.0. This improved to 4.6 after the course, reinforcing their strong foundation in AI-related tools and programming.

Overall, these improvements across all areas show a deepened understanding and increased confidence among students in handling GAI technologies and LLMs like ChatGPT, equipping them to tackle real-world challenges more effectively. The high ratings in the post-course survey reflect a significant enhancement in both theoretical knowledge and practical applications, resulting in a well-

	Pre Course Survey	Post course Survey
Q1	How would you rate your understanding of Generative AI concepts?	How much has your understanding of Generative AI concepts improved after this course?
Q2	How familiar are you with Large Language Models like ChatGPT and Google Gemini?	How would you rate the improvement in your skills related to Large Language Models (LLMs) as a result of this course?
Q3	Rate your experience with prompt engineering for enhancing large language model outputs?	How effective do you find yourself in applying prompt engineering techniques after the course?
Q4	How would you rate your hands-on experience with implementing, training, or customizing Large Language Models in projects or research?	How well do you feel prepared to apply the knowledge and skills from this course to real-world problems?
Q5	Rate your technical background in programming languages and tools relevant to AI development?	Overall, how satisfied are you with your learning experience in this course?

TABLE I: Survey Questionnaire

rounded learning experience.

The results from the pre-course survey, shown in Fig.3, and the post-course survey, shown in Fig.4, illustrate the cumulative distribution of participant responses. These results reveal a distinct shift towards higher ratings in the post-course survey across all questions, suggesting that the course had a positive impact on participants. This is evidenced by the steeper curves in the post-course graph, particularly for Q1, which increased from 55% to 75%, and Q3, which rose from 50% to 70%. Before the course, the average rating for most questions was around 3, but it increased to 4 afterward. Additionally, the increased steepness of the post-course graph's curve, especially notable between ratings of 3 to 5, denotes a distinctly more positive response among participants. This is further exemplified by the shift in the 80th percentile, ascending from a rating of 3.5 before the course to 4 after its completion. This general shift towards higher ratings in the post-course CDF indicates higher satisfaction among the participants, clearly demonstrating that our mini-GAI course helped students understand and gain confidence in GAI concepts.

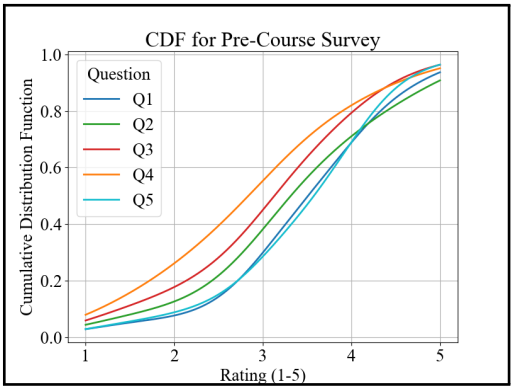

Fig. 3: Pre-Course Survey CDF Graph

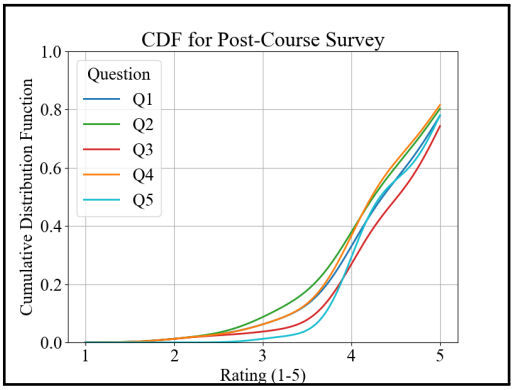

Fig. 4: Post-Course Survey CDF Graph

B. Qualitative Approach

For this approach, we conducted in-class feedback sessions to gather further insights from students. Additionally, we requested them to submit feedback along with their hands-on exercises and mini-projects on Canvas. After carefully evaluating their responses, we discovered several insightful observations.

- **Feedback and Observations on Lectures**: Feedback from the lectures showed that students greatly appreciated the integration of the mini-course and observed significant advancements in their understanding of GAI technologies, particularly in prompt engineering and fine-tuning with ChatGPT. However, they encountered challenges in grasping more advanced customization techniques such as Retrieval-Augmented Generation (RAG). Some notable observations and student comments are listed below:

Observation 1

1) Students tried to connect the learning from the course to real-world industry trends, demonstrating its relevance and practical use cases.
2) Initial challenges with understanding complex AI concepts suggest a need for additional instructional support or resources.
3) Significant transformation in how students approach and utilize ChatGPT, highlighting their enhanced interaction skills.

Student Comments: Here are some of the comments obtained from the students on the mini-GAI course lectures: *"It was a good interactive session. Learned a lot of new things about Generative AI.", "I think we could have more of these.", "Introduction to a completely new topic, Generative AI, this session provided me with a solid foundation. I have acquired practical knowledge in new areas through this mini course."*

- **Feedback and Observations on Hands-on Labs**: Feedback obtained from the hands-on exercises on lecture topics such as prompt engineering, fine-tuning, and Retrieval-Augmented Generation (RAG) using ChatGPT was positive. Students valued the interactive sessions and appreciated using tools like Gradio, Git, and Google Colab to apply their learnings practically. These exercises improved their understanding and implementation of AI in real scenarios. However, challenges with datasets and setups indicate a need for better introductory resources.

Observation 2

1) Students are effectively applying prompt engineering techniques in their interactions with large language models.
2) Improved ability in optimizing AI models for unique applications and data handling abilities.
3) Hands-on exercises enhanced the effectiveness of the learning approach.

Student Comments: Students comments on different hands-on labs include *"Learning how to effectively use the LLMs was a great learning experience.", "I thoroughly enjoyed the session as it provided invaluable insights into harnessing the power of pre-trained models and tailoring them to suit specific dataset a skill set I previously lacked. ", "I learned how to connect external tools like Git with the LLM, which is super useful for real-world tasks. Overall, it was an awesome learning experience that I can put right to work on my projects.*

- **Feedback and Observations on mini-project**: For our mini-course, we collected 42 individual student projects that demonstrated their understanding of the course content and their effective application of fine-tuning ChatGPT to enhance their learning experience of AI concepts from various perspectives. Notable mini-projects included fine-tuning models to deepen their knowledge of machine learning and exploring the intricacies of the K-Means clustering algorithm. Additionally, students developed AI-based recommendation systems tailored to various domains such as healthcare, travel, automotive, and insurance, showcasing the diverse applications of AI techniques in real-world scenarios.

Student comments: Below are some of the student comments obtained from the feedback on the mini-project,*" Working on my mini-project significantly deepened my understanding of K-means clustering algorithms. To create my dataset, I gathered data from various online resources, which enhanced my practical experience and familiarity with applying these concept., "This task provided me with valuable insights into the process of fine-tuning. Through this assignment, I gained proficiency in utilizing Open AI for fine-tuning purposes using various datasets.", "Working on fine-tuning LLMs was enjoyable and enlightening. Using the OpenAI API for fine-tuning was straightforward, enhancing my confidence in its application."*

Observation 3

1) Students have developed a deeper understanding of host course concepts through their mini-project implementations.
2) They have gained more confidence in utilizing customization techniques to create their own fine-tuned models.
3) There has been an increased curiosity towards learning advanced AI concepts.

- **Areas of Improvement**: This was our first time integrating a GAI mini-course into a graduate-level AI course, and we were open to feedback for improvements from the students' perspective. Based on their feedback, students identified some notable areas for improvement, such as: *"Increase the course materials to provide better explanations.", "provide more hands-on lab excercises.", "Could be a follow along session for longer span of time."* Additionally, some students felt like *"This course could be longer, covered over 4 weeks."*

V. Conclusion

The integration of a Generative AI (GAI) mini-course into a graduate computer science curriculum using a Project-Based Learning (PBL) approach has significantly enhanced learning outcomes. This module has deepened students' understanding of GAI concepts and bolstered their practical skills through a combination of lectures, labs, and projects. The course structure promoted the practical application of GAI principles to real-world scenarios, enabling students to engage effectively with advanced tools and customize their learning experiences. Positive feedback and post-course survey results have confirmed substantial improvements in students' abilities to utilize GAI tools effectively. Given its versatility and relevance, this mini-course offers a robust framework for integrating state-of-the-art AI technologies into academic curricula, revolutionizing educational practices and equipping students with the necessary skills to navigate future technological advancements.

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