Using ChatGPT in Undergraduate Computer Science and Software Engineering Courses: A Students' Perspective.

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***Abstract*—This innovative practice full paper presents an empirical study aimed at evaluating the potential of ChatGPT, an advanced AI-driven chatbot, as a supplementary educational tool in undergraduate Computer Science and Software Engineering (CSSE) courses.**

The study, initiated in the summer of 2023, focused on assessing ChatGPT's capabilities in generating accurate and complete computer code, identifying and rectifying code defects (bugs), and its scalability in handling larger programs. To achieve this, we conducted a series of experiments with ChatGPT. In one experiment, we introduced bugs into small programs from introductory CSSE courses. ChatGPT was tasked with detecting these defects and providing recommendations for fixing them. We evaluated ChatGPT's effectiveness in bug detection, the quality of its recommendations, and the completeness of the proposed solutions. We sought answers to questions such as whether ChatGPT found all injected defects, provided appropriate recommendations, and delivered high-quality solutions based on criteria like code completeness, size, complexity, and readability. In another experiment, ChatGPT was asked to generate code for assignments from previous CSSE courses, including Intro to Computer Science and Programming in C++, Intro to Python Programming, and Object-Oriented Programming and Data Structures using Java. We assessed the generated code's correctness and quality in comparison to student-written code. Similarly, in a third experiment, we evaluated ChatGPT's ability to generate larger programs using requirement specifications from an upper-division CSSE course on Agile Software Engineering.

Analyzing both qualitative and quantitative data from these experiments during the summer, we determined that ChatGPT showed promise as an educational tool. Consequently, we developed a plan to integrate ChatGPT into select CSSE courses for the fall semester of 2023. Specifically, ChatGPT was integrated into two of our introductory CSSE courses enabling students to utilize it for debugging assignments and generating practice questions for exam preparation. In addition, we encouraged student teams in our EPICS (Engineering Projects In Community Service) course to utilize ChatGPT as a supplementary aid to help them find and learn any new programming languages or technologies needed for their projects.

Anonymous surveys were conducted at the beginning and at the end of these courses to collect feedback from students regarding their experiences with ChatGPT. Initial responses indicated that students were generally familiar with ChatGPT and expressed curiosity about its potential utility, although some skepticism was present. However, by the semester's end, students demonstrated a positive shift in perceptions. They appreciated ChatGPT's assistance in rectifying code bugs, especially after-hours. Additionally, students valued ChatGPT for generating practice questions for exams, despite some inconsistencies in its responses. In our EPICS course, students felt ChatGPT was useful for learning new technologies, though opinions varied on its project management benefits. Lastly, the majority of students felt that ChatGPT helped them adjust to their work progress, showing its potential utility in keeping pace with ongoing projects.

Based on student feedback, we propose integrating ChatGPT into future CSSE courses. Finally, as AI-based tools become more integral to academic settings, we believe that disseminating our experiences could potentially enhance engineering and computing education.

Keywords— AI, GenAI, Chatbot, ChatGPT, Software Engineering, Computer Science Education, EPICS

I. INTRODUCTION

In the ever-evolving landscape of technological education, chatbots, specifically advanced AI-driven chatbots like ChatGPT, have emerged as promising tools in enhancing the overall learning experience. In addition, chatbots, once simple text-based interfaces designed for rudimentary interactions, have now evolved into sophisticated platforms capable of understanding and generating human-like text, providing

personalized learning experiences and facilitating interactive learning environments.

In particular, the integration of such chatbots into Computer Science and Software Engineering (CSSE) education marks a pivotal shift in pedagogical approaches. The importance of such research area stems from the growing demand for effective, scalable, and interactive educational tools in the CSSE field. These disciplines are characterized by rapid technological advancements and require educational methodologies that can adapt accordingly. Chatbots like ChatGPT, with their ability to process and generate language-based responses, demonstrate a promising and innovative approach to meet these educational needs.

Previous research in this domain has primarily focused on the use of chatbots for basic educational purposes, such as answering FAQs (Frequently Asked Questions), guiding students through course materials, or providing feedback on assignments. However, our research aims to delve deeper, exploring the potential of ChatGPT as a supplementary teaching tool in the realms of coding and software development. Specifically, we aim to understand how ChatGPT can aid in teaching coding practices, and problem-solving skills in CSSE courses. So, for the purpose of this research, we hypothesize that an AI-based chatbot such as ChatGPT may be perceived by CSSE students as a helpful learning tool during their computer programming courses.

Furthermore, by examining the capabilities of ChatGPT and its application in an educational setting, this study hopes to establish a pathway towards a broader understanding of AI's role in education, particularly in disciplines that are heavily reliant on evolving technologies such as CS and SE. Moreover, our research is motivated by the need to explore innovative teaching methods that can complement traditional educational approaches, potentially transforming the learning experience for students in the CS and SE disciplines.

The rest of this paper is organized as follows: Section II describes a related literature review, followed by section III which presents our empirical study. Sections IV and V discuss and summarize the results of the study. The last section VI concludes by suggesting some future steps and directions.

II. LITERATURE REVIEW

The advent of AI-driven chatbots, notably ChatGPT, represents a significant shift in pedagogical strategies, particularly within Computer Science and Software Engineering (CSSE) disciplines. These tools, characterized by their sophisticated design and integration into the academic sphere, offer innovative approaches to learning, emphasizing personalized and interactive engagement. Studies such as those by P. C. Ramos Pinho and T. T. Primo in their FIE 2023 paper on Chatbots [1] have noted this shift, illustrating ChatGPT's capacity to augment traditional teaching methods significantly by providing tailored learning experiences. These findings resonate with our research, highlighting ChatGPT's adaptability to various learning styles and proficiencies.

The use of ChatGPT as a virtual peer in computer programming instruction has shown marked improvements in student learning outcomes. As highlighted in "Challenging the Confirmation Bias: Using ChatGPT as a Virtual Peer" by O. L. Dos Santos and D. Cury, this innovative approach has led to enhanced programming skills, surpassing traditional methods [2]. However, these advancements come with challenges in handling abstract concepts, reflecting our observations in this research. Simultaneously, ethical considerations in deploying AI tools like ChatGPT, as discussed in M. Morsy, A. Farraj, and D. Reavis's work "On the Challenges and Opportunities of Using ChatGPT in Academia", underscore the need for a balanced integration of these technologies into educational frameworks, balancing potential drawbacks with significant benefits [3].

The scope of ChatGPT's application in education, as explored by various scholars, demonstrates its multifaceted potential. Chung Kwan Lo's study emphasizes ChatGPT's broad applicability across different subject domains, enhancing understanding and engagement in educational environments [4]. Additionally, a special issue edited by Prof. Dr. Longkai Wu and Prof. Dr. Hung Wei Loong David showcases the diversity of ChatGPT's applications, ranging from inquiry-based learning to language practice and educational assessment, supplementing our own research goals on ChatGPT's effectiveness in task structuring and code generation [5].

Complementing these insights, Marta Montenegro-Rueda et al. provide a systematic review of ChatGPT's practical applications in education, observing its positive impact on teaching and learning [6]. Similarly, Zhai [7], Lund and Agbaji [8], and Susnjak [9] discuss ChatGPT's wide-ranging influence across various educational settings, including automated assessment in science education and online test security, highlighting its capacity for both teaching and assessment.

In specialized fields, Biswas [10], Sobania et al. [11], Pavlik [12], and Jeblick et al. [13], investigate the applications of ChatGPT in areas including climate forecasting, journalism, advanced programming techniques, and medical education. These studies collectively underscore the versatility and significance of ChatGPT across a range of academic disciplines. For instance, Jeblick et al. [13] examines how ChatGPT can simplify intricate radiology reports, which aligns with the potential advantages of employing AI to clarify complex programming concepts for students enrolled in introductory computer science courses. This illustrates how ChatGPT can be customized to address the unique requirements of various educational settings by transforming complicated information into more accessible formats, a feature that is especially beneficial for novices in the field of computer science. Moreover, Chavez et al. [14] and Kasepalu et al. [15] emphasize ChatGPT's implications in educational planning and teacher assistance, showcasing its utility in broader educational strategies.

Recent studies by Neuman, Rauschenberger, Schön [16], Qadir [17], and Wang et al. [18] underscore the transformative potential of AI tools in higher education, advocating for their integration into curricula to enhance personalized learning experiences. Similarly, Kevin Fuchs's exploration of NLP models in education [19] and Mohanad Halaweh's research on responsible implementation strategies [20] highlight the opportunities ChatGPT presents in enhancing educational experiences and addressing potential challenges.

Md. Mostafizer Rahman and Yutaka Watanobe delve into ChatGPT's multifaceted role in education and research, emphasizing its capabilities in facilitating research and improving educational practices [21]. Ausat et al. provide a fundamental analysis of ChatGPT's potential to augment the educational process, suggesting its role as a supportive tool rather than a replacement in classrooms [22]. This is complemented by Mehmet Firat's research, which reflects positive perceptions of ChatGPT among scholars and

students, indicating its potential to enhance academic experiences and outcomes [23]. Studies such as those by Fauzi et al. emphasize the significant contributions ChatGPT makes in enhancing student productivity through providing valuable resources, improving language skills, and facilitating collaboration [24]. Similarly, Lund and Wang discuss ChatGPT's potential to revolutionize academic and library services, highlighting its capabilities in search and discovery, reference services, and content creation, while also addressing ethical considerations like privacy and bias [25].

Recent research, including the work of Sadik et al. [26], delves into the utilization of ChatGPT within educational environments, particularly in the realms of software development and programming. This investigation assesses the potential of ChatGPT in various tasks such as code generation, debugging, and code refactoring—key components of introductory programming courses. The findings suggest that although ChatGPT cannot substitute for human programmers, it significantly enriches the educational experience by offering prompt feedback and personalized support, which is especially advantageous for novice learners. The insights provided by Sadik et al. [26] align with our emphasis on the practical application of ChatGPT in foundational computer science courses, highlighting its capacity to enhance comprehension of programming principles and improve student performance.

In summary, the literature robustly advocates for the integration of AI-driven tools like ChatGPT in education, citing their capacity to revolutionize traditional learning paradigms. These tools foster enriched, adaptive learning environments and challenge educators and students to rethink the dynamics of knowledge acquisition and application in the digital age.

The rest of this paper presents an empirical study which aims at expanding existing research by exploring the potential and limitations of ChatGPT used as a supplementary teaching tool specifically for undergraduate CSSE courses.

III. EMPIRICAL STUDY

We launched an empirical study to explore the potential and limitations of ChatGPT as a supplementary teaching tool in undergraduate Computer Science and Software Engineering (CSSE) courses. The study was conducted in two separate stages.

During the first stage (summer 2023), we focused on assessing ChatGPT's capabilities in generating accurate and complete computer programs given as assignments in past introductory computer programming courses. Moreover, we wanted to test the tool's effectiveness in identifying and rectifying code defects (bugs) and its ability to handle larger programs (i.e. software projects from upper division CSSE courses). To this end, we conducted a series of experiments with ChatGPT which are described in the following sections.

In the second stage of our study and based on the promising results gathered from the first stage, we decided to incorporate ChatGPT into select CSSE courses during the following semester (fall 2023). More specifically, ChatGPT was integrated into two sections of our introductory Python programming course and one section of our service-learning project-based course called EPICS (Engineering Projects In Community Service) where teams of students work for a nonprofit organization in the community [27].

Our overall goal was to enable students to utilize ChatGPT for various course activities such as debugging assignments, generating practice questions for exam preparation and learning new technologies used in our EPICS projects. Anonymous surveys were conducted at the beginning and at the end of these courses to collect feedback from students regarding their experiences with ChatGPT. All these experiments and survey results are described in more detail in the following sections.

A. Assessing ChatGPT's potential and limitations

All the experiments conducted during our first stage using ChatGPT are summarized in Table I. With these experiments we aimed at measuring ChatGPT's ability to find defects, recommend effective solutions, generate complete executable code of high quality and be able to handle larger size computer programs.

More specifically, during these experiments, ChatGPT was tasked with creating a total of twenty introductory-level programs, diversely distributed across C++, Python, and Java, with six programs in C++, six in Python, and eight in Java. For each program, ChatGPT was given up to three attempts to generate a functional output. The success of each attempt was evaluated by running the produced code. If the code failed to execute successfully, ChatGPT was provided with feedback, including any logic or syntax errors identified or output from the program's execution. This feedback was used to inform subsequent attempts, simulating a realistic coding, and debugging process. Additionally, ChatGPT was requested to provide initial steps for each assignment from the perspective of a teacher aiding a student, evaluating its ability to mimic an educator's approach to guiding students through problem-solving in coding.

TABLE I. ASSESSING CHATGPT'S POTENTIAL AND LIMITATIONS

Experiment	*Metrics*	*Assessment*
Infuse defects in small size computer programs (i.e. introductory CSSE course assignments) and ask ChatGPT to find them.	Effectiveness	Did ChatGPT find all the injected defects? Did it miss any defects and why?
Ask ChatGPT to recommend solutions on how to fix the above injected defects.	Feasibility of recommended solutions	Did ChatGPT make appropriate recommendations on how to fix the defects? Did it provide a complete solution on how to fix them? Can the proposed solutions be easily understood and implemented?
Infuse defects in larger size computer programs (i.e upper division CSSE course projects) and ask ChatGPT to locate them and recommend a solution on how to fix them.	Scalability	Can ChatGPT find defects in larger size programs and provide effective solutions? Can it handle larger size programs?
Provide ChatGPT with requirements of a CSSE course assignment and ask it to generate a complete computer program written in a specific programming language.	Completeness and correctness	Did ChatGPT automatically generate a complete, syntactically and logically correct program that can be executed and produce the expected output?
Review the automatically generated code by ChatGPT for the above requirements specifications.	Quality of code	Is the automatically generated code of high quality based on some criteria including completeness, size, complexity, accuracy, and readability?

Furthermore, for each programming task, ChatGPT was required to produce detailed pseudocode (i.e. combination of an algorithmic narrative description and computer code), helping us understand how it conceptualizes and structures programming logic before translating it into actual computer program.

In addition, we ran separate experiments where we injected defects into programming assignments from previous introductory programming courses and asked ChatGPT to locate them and provide recommendations on how to fix them. We then assessed the degree of success of the defect identification and suggested resolution using the criteria shown in Table I. These criteria include the number of defects identified, number of defects corrected, number of lines of code, complexity of code used for defect correction, and readability of the proposed corrections.

Based on the promising results gathered from the first stage of our study we decided to proceed with the second stage outlined below.

B. ChatGPT Classroom Integration

Table II below summarizes the activities during the second stage of our empirical study, where we integrated ChatGPT into select CSSE courses during the fall 2023 semester. Specifically, ChatGPT was used into two sections of our introductory Python programming course and one section of our service-learning, project-based EPICS (Engineering Projects In Community Service) course [26].

During the classroom integration process, students were encouraged to use ChatGPT for assistance with their programming assignments and submitted brief reflective reports on their experiences. These reports provided qualitative data on ChatGPT's utility in coding tasks and its outputs for correcting and completing their assignments. In addition, we designed comprehensive surveys administered before (pre-survey) and after (post-survey) the experiment. These surveys aimed to capture students' initial perceptions and subsequent experiences with ChatGPT, focusing on its utility as a supplementary learning tool.

TABLE II. CHATGPT CLASSROOM INTEGRATION

Class Name	*Semester Offered*	*Programming Language*	*Student Count*	*ChatGPT Activities*
SE132_01: Introduction to Python Programming	Fall 2023	Python	19	Code defects discovery & resolution. Practice exam questions
SE132_02: Introduction to Python Programming	Fall 2023	Python	17	Code defect discovery & resolution. Practice exam questions
EPICS (Engineering Projects In Community Service)	Fall 2023	Various languages including C#, HTML, SQL, Swift, Java, React	28	Teams used ChatGPT to explore and test various new technologies.

The pre-course survey was divided into various questionnaires, covering demographics, initial familiarity and perception of ChatGPT, and expectations from ChatGPT's utility in several educational activities for both SE132 and EPICS course participants. The post-course survey mirrored the specific questions from the pre-course sections on utility, asking students to rate the actual assistance received from ChatGPT across the same areas. The survey also allowed for open-ended feedback from students about their personal experiences and feelings, including any perceptions of ChatGPT as a cheating tool, confusion, or disappointment with the outcomes.

IV. RESULTS

This section describes the results of our empirical study gathered during our two stages separately. Namely during the experiments assessing ChatGPT's potential and limitations (Stage 1) and our efforts to integrate ChatGPT in the classroom (Stage 2).

A. Stage 1 Results

Table III summarizes the performance of ChatGPT when it was tasked with detecting and correcting errors in Python, Java, and C++ programming assignments. ChatGPT reviewed these programming assignments that contained intentionally injected defects and achieved a detection and solution accuracy of 95.83% for Python, 93.75% for Java, and 87.60% for C++, as shown in Table III.

TABLE III. PERFORMANCE ANALYSIS OF CHATGPT'S ABILITY TO LOCATE AND PROVIDE SOLUTIONS FOR SYNTACTICAL AND LOGICAL ERRORS

Computer language	*Number of programming assignments*	*Number of injected defects*	*Defects found by ChatGPT (1 attempt)*	*Remarks*
Python	6	24	95.83% (23/24)	Only one mistake was not detected, and it was in regard to a rounding instruction. Every syntax error was caught. Every detected error was also corrected without issue.
Java	8	32	93.75% (30/32)	Only two mistakes were made but they were both made on the "Wumpus" program which contained multiple files and a comparatively long main file. This suggests ChatGPT may struggle with longer program analysis.
C++	6	24	87.50% (21/24)	The program made mistakes that again mostly depended on the logic concerning math computations.

While ChatGPT was effective in identifying syntax errors and making corresponding corrections, it also showed issues when presented with larger programs such as the multi-file

assignment called “Wumpus” from the Java language, and mathematical computations in C++ assignments.

Additional results gathered from the experiments of the first stage are summarized in Table IV. This table entails data about the success rate and efficiency of ChatGPT-generated code given as assignments in three past CSSE courses including Introduction to Python Programming, Object-Oriented Programming and Data Structures (Java), and Introduction to Computer Science and Programming (C++). ChatGPT achieved a 100% success rate in Python and Java assignments, with an average of 1.33 and 1.625 trials needed, respectively, indicating high effectiveness in handling assignments, even those with complex requirements in Java. In contrast, the success rate in C++ was lower at 83.33%, with one outright failure due to exceeding the maximum trial attempts, primarily because of mathematical computation errors. The data highlights ChatGPT's promising performance across different programming languages, a varying complexity of assignments, as well as its efficacy in programming assignments across various CSSE courses.

Regarding scalability, a notable example is in asking ChatGPT to design a software application for an IT Service Help Desk, where ChatGPT successfully decomposed the project into manageable parts, adjusted to evolving requirements, and provided detailed Python code for specific functionalities.

In terms of condensing and summarizing skills, ChatGPT excelled in breaking down complex tasks into simpler components, effectively aiding in advancing student comprehension. This was evident in its handling of a Banking Application project, where it smoothly transitioned from pseudocode to actual Python code, showcasing its ability to guide learners through their individual progressive stages of understanding.

TABLE IV. EFFICACY OF CHATGPT IN PROGRAMMING ASSIGNMENTS ACROSS DIFFERENT COMPUTER SCIENCE COURSES

Programming Language	*Number of Programming Assignments*	*Number of Successful Project Completions*	*Average Trials Required for Success*	*Remarks*
Python	6	6 (100%)	1.33	All programs were generated to assignment specifications
Java	8	8 (100%)	1.625	All programs were generated to assignment specifications
C++	6	5 (83.33%)	1.2 and 1 Failure	ChatGPT failed to complete a grade calculation assignment, demonstrating its struggles with mathematical computations.

Table V presents an analysis of computer programs generated by ChatGPT, detailing various programming assignments across Python, Java, and C++. Specifically, all metrics used to assess the quality of each generated program are summarized in the table including their total lines of code, their number of comment lines and their cyclomatic complexity (i.e., the level of nesting of decision and iterative statements). The programming assignments given to ChatGPT included standard tasks like Celsius to Fahrenheit conversion, grade calculation, and sales tax calculation, alongside more complex projects such as Wumpus, a 9-tile maze game; La Food, which calculates average waiting times at a restaurant; Camp Posanivee, which manages campers using a binary search tree; and Collatz, which explores the Collatz conjecture to find the maximum sequence length between two numbers.

Based on these collected measurements shown in Table V and after comparing ChatGPT’s generated code with the code written by students for their assignments, we concluded that both programs were of similar high quality.

TABLE V. ANALYSIS OF CODE GENERATED BY CHATGPT

Assignment	*Programming Language*	*Cyclomatic Complexity*	*Lines of Code*	*Lines of Comments*
Sales Tax	Python	1	22	9
Software Sales	Python	6	43	11
Celsius to Fahrenheit	Python	9	27	5
Paint Job	Python	7	62	9
Paint Job Refactorization	Python	7	66	13
Web Page	Python	6	36	10
Guessing game	Java	6	37	8
Exam Statistics	Java	4	64	10
Date	Java	19	92	16
Wumpus	Java	37	129	22
La Food	Java	9	62	9
Sorting	Java	23	90	11
Camp Posanivee	Java	25	179	26
Jerry-Tac-Toe	Java	8	142	22
Prime	C++	13	82	10
Area Calculator	C++	1	29	5
Monty Python	C++	5	42	7
Collatz	C++	9	48	8
Word Reversal	C++	6	42	11

We also found a correlation between the specificity of user input and the effectiveness of ChatGPT's responses. In a unique task involving the creation of a specialized version of a Tic-Tac-Toe game, ChatGPT developed a Java program with a GUI (Graphical User Interface) and AI logic, adhering to the specific rules of the game. However, the study observed some limitations in ChatGPT's responses, such as occasional

repetitiveness and resulting implementation challenges. On the other hand, ChatGPT displayed strong conversational capabilities, effectively engaging in dialogue to troubleshoot and guide users through programming challenges. This was illustrated during a Java program troubleshooting session, where ChatGPT adopted a tutoring role and promoted active learning through carefully crafted questions and hints. Figure 1 below depicts an example of a helpful conversation with ChatGPT conducted during the ICSM project.

Tester: "Ok, now I noticed that the expected wait time is not calculated correctly. Does this program take into account party size when making such a calculation?"

ChatGPT: "You're on the right track! The calculation of the average waiting time is indeed based on the total waiting time and the total number of customers.

The average waiting time should be calculated as the total waiting time divided by the total number of customers. And as you might have inferred, the total number of customers comes from the size of each party.

So, if your calculation is not considering the party size, that would mean the number of customers might not be being counted accurately. This would lead to an incorrect calculation of the average waiting time.

Could you locate the part in your code where you increment the total number of customers? Are you taking into account the size of the party (number of people in the party) when incrementing the total number of customers?"

Fig. 1: Example of conversing with ChatGPT.

In terms of code generation and explanation, ChatGPT proved adept at generating and explaining code, as seen in its successful creation of a functional C++ program based on complex requirements. Its ability to switch programming styles and provide syntactically correct code was noteworthy, achieving a 95% success rate for generating an entire introductory level CSSE project according to directed specifications within three attempts.

Lastly, the AI's capacity to structure complex tasks into smaller, manageable units was a significant highlight. For instance, in designing an Insurance Claim Management System (ICMS), ChatGPT demonstrated excellent task decomposition and modularity, essential for understanding large-scale software development.

B. Stage 2 Results

This section describes all the results gathered during the integration of ChatGPT in the classroom. Specifically, we first present the quantitative data collected from 52 students surveyed, which includes 35 participants from the SE132 class and 17 from the EPICS course. The data was collected using a Likert scale [28], where students rated their experiences on a scale ranging from "Definitely Not" to "Definitely Yes." The quantitative data is followed by qualitative insights gathered from the open-ended responses in the student surveys.

a) Quantitative Survey Results

Table VI summarizes survey results gathered from students evaluating the effectiveness of ChatGPT as a learning tool during our EPICS service-learning course [26]. The majority (67%) found ChatGPT to be a useful learning tool overall, and the same percentage noted its usefulness in learning new technologies. However, opinions varied more on its benefits for project management tools and preparing professional presentations, with no clear majority either in favor or against. Lastly, 67% of the students felt that ChatGPT helped them adjust to current work progress, showing its potential utility in keeping pace with ongoing projects.

TABLE VI. SUMMARY OF STUDENT FEEDBACK ON THE USEFULNESS OF CHATGPT IN A SERVICE-LEARNING COURSE (EPICS)

Survey Questions	*Yes*	*Somewhat*	*No*
Did you find ChatGPT to be a useful learning tool during this course?	67%	33%	0%
Did it help you learn new technologies and/or platforms?	67%	0%	33%
Did it help you learn new project management tools?	0%	67%	33%
Did it help you prepare a professional final presentation?	33%	33%	33%
Did it help you to adjust to current work progress?	67%	0%	33%

Moreover, Table VII shows the effectiveness of ChatGPT as reported by students in a Python programming course, covering aspects such as code debugging, exam preparation, assignment completion, and learning enhancement. Notably, 60% of students found ChatGPT helpful in identifying syntax or logical errors in their code. In contrast, opinions were mixed regarding its help in preparing for exams, with only 40% finding it beneficial and 50% not. About learning enhancement, 63% viewed ChatGPT as a useful tool overall, but responses varied across specific learning activities like generating pseudocode algorithms and understanding related material. The feedback underscores the tool's varied impact on different aspects of the learning process in programming education.

TABLE VII. SUMMARY OF STUDENT FEEDBACK ON THE UTILITY OF CHATGPT IN A PYTHON PROGRAMMING COURSE

Survey Questions	*Yes*	*Somewhat*	*No*
Did ChatGPT help you find syntax or logical defects in your code?	60%	20%	20%
Did ChatGPT help you prepare and study for exams?	40%	10%	50%
Did ChatGPT help you practice and better understand the textbook?	40%	30%	30%
Did ChatGPT help you understand what you did wrong in an assignment and how to fix it?	55%	27%	18%
Did ChatGPT help you get started on your assignments?	36%	18%	46%
Did ChatGPT help you generate an algorithm in pseudocode for your assignment(s)?	20%	40%	40%
Did ChatGPT help you learn more related material?	27%	46%	27%
Did ChatGPT help you complete assignments successfully and on time?	30%	30%	40%
Did you find ChatGPT to be a useful learning tool during this course?	63%	27%	10%

As shown in Figure 2, the pie chart depicts the major fields of study among students enrolled in the courses. The largest segment consists of students in CSSE, making up 32% of the population. The second largest is Business Analytics, with 26%. Natural Sciences represent 13% of the student body, while both Finance and Mathematics are pursued by 8% each.

Social Sciences and Other unspecified majors each constitute 5%, and Engineering is the least represented at 3%. This distribution highlights the predominance of computer-related fields within this particular student selection.

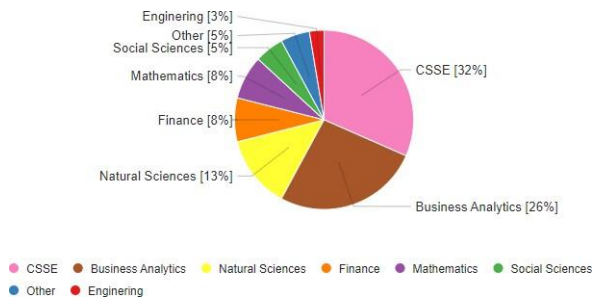

Fig. 2: Distribution of Enrolled Student Majors

Figure 3 illustrates that a vast majority of students (97%) had heard about ChatGPT, indicating a high level of awareness about the tool prior to its introduction in these courses. In figure 4, a substantial proportion of students (82%) reported having previously used ChatGPT, suggesting its widespread adoption as a resource among students prior to its usage in these courses.

Fig. 3 and 4: Student Awareness and Prior Experience with ChatGPT

Figure 5 reveals that a majority of students believed in the potential of ChatGPT to assist them in their studies, with 55% saying 'Definitely yes' and 29% inclined to agree, stating 'Probably yes'. This optimism towards ChatGPT reflects its perceived utility as an educational tool.

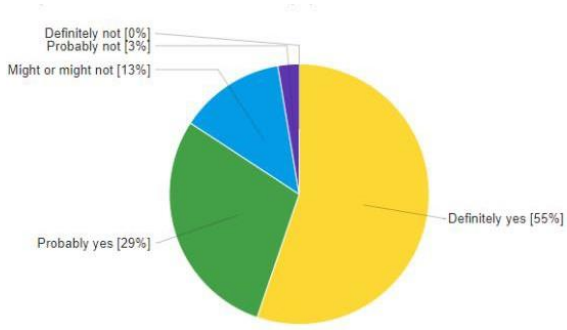

Fig. 5: Student Expectations of ChatGPT as a Learning Aid

Figure 6 reflects student sentiment about whether ChatGPT could help complete assignments on time. A majority were uncertain, with 58% responding 'Maybe', while 38% did not believe it will help, and a small minority of 4% were confident that it will assist them. Figure 7 illustrates that students' expectations for ChatGPT's ability to identify coding defects were positive, with 71% answering 'Yes', suggesting a strong belief in ChatGPT's capability to assist with coding issues. Meanwhile, 21% were on the fence, and only 8% did not expect ChatGPT to be helpful in this regard.

Fig. 6 and 7: Student Confidence in ChatGPT for Assisting in Assignment Completion and Identifying/Fixing Code Defects

Figure 8 shows that 58% of students felt ChatGPT would help them learn more Python material beyond their class coverage, indicating a favorable view of ChatGPT as a supplementary learning tool. However, 29% were undecided, and 13% did not expect additional learning benefits from ChatGPT. When students were asked about ChatGPT's role in exam preparation, their responses were split as shown in Figure 9. More specifically, 29% believed ChatGPT will be helpful, 29% were unsure, and 42% did not think ChatGPT would aid in their exam studies. This indicates mixed expectations regarding the effectiveness of ChatGPT as a study aid for exams.

Fig. 8 and 9: Anticipated Benefit of ChatGPT in Learning Additional Python Material and Student Opinions on ChatGPT's Usefulness for Exam Preparation

b) Qualitative Survey Data

We received various responses commenting on ChatGPT's ability to help students enhance the quality of their code as well as its overall effectiveness as a learning tool. Moreover, some responders described challenges they faced with the complexity of ChatGPT's answers. Student responses are grouped in separate themes and described next.

Enhancement of Code Quality: Students appreciated how ChatGPT contributed to the improvement of their coding practices by offering them more detailed algorithms and reminding them of potentially necessary steps while working on their programming assignments. Selected related quotes are shown below.

"ChatGPT helped me make my algorithm more detailed which really helped me keep track of what I actually needed in my code."

"It was nice comparing ChatGPT's algorithm to my original one because it reminded me of some of the steps I would have originally forgot."

Overall Effectiveness as a Learning Tool: Several survey respondents highlighted ChatGPT's effectiveness functioning as an educational tool, particularly praising its utility and usefulness for beginners and its ability to teach or provide alternative approaches to completing programming tasks. Here are a few selected student quotes:

"ChatGPT would be a great tool for someone new to Python, or for someone doing complex code!"

"ChatGPT gave me the opportunity to check my work and see a different variation of how to run the program."

We found the following response particularly interesting describing how a student felt about the overall use of ChatGPT.

"ChatGPT is like having a smart friend who knows a lot about everything. It can help you learn by explaining things in simple words and answering your questions about all kinds of stuff. Whether you're studying for school or just curious about something, ChatGPT can give you helpful information and even spark your creativity. It's like having a handy teacher or study buddy right at your fingertips, making learning easy."

***Complexity of Solutions**:* Some potential drawbacks of ChatGPT were identified and mentioned in several responses. The most prominent being a concern regarding the complexity of solutions provided by ChatGPT. These solutions were perceived too complex by some students and may overwhelm them. For instance, one student said:

"I found the algorithm that ChatGPT gave was a bit too complicated."

In the following sections, we conclude by summarizing the results of our empirical study and present some future research directions.

V. DISCUSSION

Based on the collection and analysis of all our empirical and survey data, valuable insights were gathered regarding the impact of ChatGPT on the learning experiences of students in CSSE courses. Specifically, the surveys helped us assess students' perceptions of ChatGPT's usefulness, its impact on their learning process, and their overall satisfaction with it as a supplementary learning tool.

The initial survey, conducted at the beginning of the semester, focused on respondent demographics, revealing that the majority were third-year students from our Introduction to Python Programming course, representing a significant portion of the initial study group. A substantial number of these students reported having used ChatGPT prior to the study, indicating a pre-existing familiarity with the tool. Their initial perceptions of ChatGPT were generally positive, with many expressing high levels of interest and optimism, and others some skepticism, about its potential as a learning tool in their courses.

The responses from our follow-up survey, given at the end of the semester, revealed an overall improved trend in students' perceptions of ChatGPT's effectiveness as a complementary learning tool for computer programming and software development. Moreover, students rated ChatGPT favorably for its ability to aid their understanding of complex algorithmic concepts and enhance their computer programming learning experience. Specific feedback highlighted ChatGPT's helpfulness in structuring tasks, generating code, and providing conversational guidance through programming problems, alongside constructive remarks suggesting areas for improvement.

Our empirical study highlights the CSSE students' acknowledgement of ChatGPT's potential to positively impact their learning experiences, particularly in introductory computer programming courses. Therefore, our research findings support the hypothesis that students perceive the role of ChatGPT as a promising supplementary learning tool.

VI. CONCLUSION AND NEXT STEPS

In conclusion, our research study has affirmed the potential of ChatGPT as a useful tool in CSSE education. More specifically, the integration of this advanced AI chatbot into the CSSE curriculum has shown a positive impact on students' grasp of programming concepts and their problem-solving abilities. Particularly noteworthy is ChatGPT's role as a complementary element to traditional teaching methods, providing an interactive and adaptive learning experience that aligns well with the dynamic nature of CSSE education.

Looking to the future, our research aims to build upon these initial findings in several ways. First, we plan to broaden the scope and participant diversity of our studies. For instance, future studies will encompass a wider range of participants, including students from various academic backgrounds and levels, to assess ChatGPT's effectiveness across a more diverse student population. Moreover, we intend to extend and promote the use of ChatGPT in other CSSE courses which cover topics such as Machine Learning, Agile Software Engineering, Data Science and Analytics, Software Testing and Quality Assurance, as well as Software Maintenance and Evolution. This expansion is intended to enhance the generalizability of our findings and provide insights into ChatGPT's adaptability across different areas of the CSSE curriculum.

Additionally, crafting and implementing a longitudinal study will enable us to track the long-term educational impacts of ChatGPT. For example, we intend to encourage our EPICS student teams who work on long-term community service projects to continue using ChatGPT throughout several semesters and study how this impacts their overall learning and efficiency as a team. This approach aims to provide a deeper understanding of how continuous interaction with AI-based tools such as ChatGPT shapes learning and productivity outcomes over time. Moreover, continuous feedback will guide the refinement of ChatGPT's application in the classroom. This includes addressing challenges in dealing with abstract concepts and advanced problem-solving, to ensure that such tools remain a relevant and effective educational resource.

Finally, we hope that our findings will inspire others to start incorporating AI-based tools, like ChatGPT, into their own courses as supplementary aid to enhance their teaching and learning experiences.

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