

Empowering Education: ChatGPT's Role in Teaching and Learning Statistics and Data Analytics

Youqin Pan
Salem State University, USA
Jian Gu
Salem State University, USA

This paper explores the potential of using Chat Generative Pre-Trained Transformer (ChatGPT), a powerful language model, as an innovative tool to enhance education in the classroom. Drawing from firsthand experience, this paper demonstrates how ChatGPT can be integrated into the teaching and learning process of statistics and data analytics classes. We provided concrete examples of how ChatGPT can be used to clarify concepts such as p-values and confidence intervals, facilitate data analytics by providing step-by-step guidance, and provide explanations for analytical outputs. The benefits of using ChatGPT help improve student engagement, foster critical thinking, and provide personalized assistance. However, the limitations of using ChatGPT, including its potential for bias in responses, should also be addressed.

Keywords: ChatGPT, generative AI, statistics, data analytics, online teaching, personalized learning

INTRODUCTION

The renowned language model, ChatGPT, created by OpenAI, has captured global attention, empowering users with the potential of Artificial Intelligence (AI) in their daily lives. ChatGPT was first introduced to the public in November 2022, and its user base has dramatically increased since its debut. Among several chatbots leveraging deep learning to enhance their performance, ChatGPT stands out as an exemplary model. Operating as a generative AI, ChatGPT can produce content without directly copying from its source. While it doesn't possess organic creativity, it collects diverse information to respond to user-generated requests. The opportunities for integrating AI into online learning and teaching are plentiful, as highlighted by Seo et al. (2021). There are various applications of ChatGPT,

Youqin Pan is a professor of operations and decision sciences at Salem State University, Salem, Massachusetts, and can be reached at ypan@salemstate.edu

Jian Gu is a professor in the Department of Management at Salem State University, Salem, Massachusetts, and can be reached at jgu@salemstate.edu

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ranging for personalized learning for students (Popenici & Kerr, 2017) to enhanced interactivity (Javaid et al., 2023).

As more institutions struggle with the challenges of remote learning, diverse student needs, and the quest for personalized education, generative AI tools like ChatGPT emerge as potential game-changers. With its advanced conversational capabilities and intelligence to understand human inputs, ChatGPT not only provides instantaneous feedback and clarifies doubts, but also delivers content tailored to individual learners' paces and preferences. Despite a general decline in overall enrollment experienced by many institutions, distance education is witnessing growth (Allen & Seaman, 2016). Advocates of online education have emphasized the potential to offer expanded content knowledge to a diverse range of learners. However, achieving success and sustainability in an online program necessitates careful attention to various factors. According to Berry (2017a), the overall experiences of students in an online academic program is determined by their combined interactions with content, technology, and support services.

The COVID-19 pandemic expedited the digitalization process in higher education. At the beginning of the pandemic, instructors were required to swiftly transit from in-person classes to online courses, adopting a remote instructional approach. Consequently, students faced the challenge of adapting to the online environment as they were left with no other options. Amidst the hurried shift to online teaching, educators faced unique challenges in course delivery, including the necessity of instructing basic concepts, programming methods, producing accessible materials, and resolving student issues. In a virtual classroom where most students keep their cameras off, instructors have limited communication clues to adapt to in real-time. The reduced feedback often leads to fewer direct interactions between students and instructors. Additionally, students faced challenges in asking questions while engaging with asynchronous content (Flores et al., 2023).

In the post-pandemic era, both instructors and students have become accustomed to online teaching. However, there are noticeable differences in how students engage with content in online settings compared to in-person classes. Student-content interaction is defined as the way in which a student interacts with course materials to enhance their comprehension or viewpoint (Moore, 1989). In a conventional in-person course, student-content engagement entails attending lectures, completing assignments, and taking assessments, among other activities. However, in an online environment, student-content engagement involves activities such as watching instructional videos and searching for information online (Abrami et al., 2011). Challenges also arise in terms of peer-peer interaction, student-instructor interaction, and student-technology interaction in the context of online teaching. There is a lack of detailed information regarding the strategies and their effectiveness to address the issues related to interaction, especially in emergency online learning situations (Flores et al., 2023).

Studies such as Clarizia et al. (2018) have explored how chatbots can be used to deal with the challenges of inadequate student-instructor interaction. Various AI chatbots can enhance learner-instructor interaction in online learning environments. These chatbots strive to emulate human teachers and foster new knowledge (Han & Lee, 2022). For instance, Goel and Polepeddi (2016) developed an AI chatbot assistant called Jill Watson to enhance instructor-student conversations. The chatbot provides responses to student introductions, posts weekly announcements, and addresses frequently asked questions, aiming to improve the overall interaction between instructors and students.

To tackle the challenges confronting educators, researchers have explored the incorporation of artificial intelligence (AI) and natural language processing (NLP) technologies like ChatGPT to elevate teaching, whether conducted in-person or online. In this study, we explore the opportunities of leveraging ChatGPT's capabilities in teaching statistics and data analytics. Additionally, we provide examples of how ChatGPT can assist

in helping students better understand course materials and give suggestions about how students can interact with ChatGPT to obtain relevant resources, master complex concepts, and conduct data analysis. The paper provides practical implications for leveraging ChatGPT to enhance teaching and learning in statistics and data analytics.

The organization of the paper is as follows: Section 2 offers an overview of prior research on the application of AI in higher education, especially for the field of statistics and analytics. Section 3 provides illustrative instances of employing ChatGPT to address teaching challenges. Section 4 presents discussion. Section 5 wraps up the paper.

LITERATURE REVIEW

Many studies have explored the role of AI-driven chatbots in educational contexts. Recently, a growing body of research has specifically delved into the impact of ChatGPT on education, as evidenced by the works of Khan et al. (2023), Flores et al. (2023), Kasneci et al. (2023), Javaid et al. (2023), and Grassini (2023). This section provides an overview of AI's applications in higher education, particularly focusing on studies that examine the use of ChatGPT in statistics and data analytics.

1. The use of AI in higher education

Educators have different views on the impact of AI models in the education sector. While some view it as a positive advancement, others express concerns about its potential to diminish analytical abilities and encourage misconduct. Chen et al. (2020) provided a comprehensive survey of the existing landscape of AI within education, emphasizing its potential merits including tailored learning, heightened accessibility, and enhanced efficiency. They also highlighted various ethical challenges associated with the implementation of AI in education. Research has documented various chatbot systems that had been designed and developed to cater to teaching and learning within higher education. For instance, Goel and Polepeddi (2016) developed an AI chatbot assistant called Jill Watson to enhance instructor-student conversations. The chatbot provides responses to student introductions, posts weekly announcements, and addresses frequently asked questions, aiming to improve the overall interaction between instructors and students. Chatbot systems are mainly employed within an educational context for the purposes of teaching and learning (Okonkwo and Ade-Ibijola, 2021). The utilization of chatbot technology, as highlighted by Benotti et al. (2017), has the potential to establish a more personalized and immersive learning environment. Educators are recognizing the significance of employing chatbots in educational settings to offer students an engaging experience (Wu et al., 2020).

The emergence of ChatGPT will undoubtedly reshape teaching and learning methods people accustomed to. There are various applications of ChatGPT in educational settings. Kasneci et al. (2023) demonstrated that ChatGPT enhanced student engagement and facilitated experiential learning, and it also affected different aspects of education such as writing, instructional methods, and teaching approaches. Facilitated by ChatGPT, students can easily engage in various activities ranging from creating computer programs to solving mathematical problems (Javaid et al., 2023). ChatGPT can make a meaningful contribution to peer tutoring as well. Research by Pardos and Bhandari (2023) revealed that the hints provided by ChatGPT in elementary and intermediate Algebra topics led to positive learning gains for students in 70% of cases. ChatGPT has also seen numerous applications in the area of medicine and public health. Khan et al. (2023) conducted research focusing on the potential uses of ChatGPT within medical education, they found that ChatGPT facilitated personalized learning and the creation of case studies. ChatGPT makes it possible for both instructors and students to create a diverse range of materials, such as discussion topics, prompts, puzzles, and others (Shahriar & Hayawi, 2023). Grassini (2023) examined the

possibilities and challenges that come with the implementation of OpenAI's ChatGPT in education. The author contended that incorporating ChatGPT into education could represent a meaningful stride, driven by the importance of an AI-dominated future. Moreover, offering students hands-on experience with these AI tools improves their understanding and practical application while also drawing attention to their limitations and keeping up with technological advancements.

While incorporating ChatGPT into education has its benefits, some studies have highlighted its limitations and the challenges of using ChatGPT in an educational setting, such as response bias and inaccurate information (Lund & Wang, 2023; Gill et al., 2024), plagiarism (Geeling et al., 2023; Rudolph et al., 2023, Cribben and Zeinali, 2023), digital divide (Gill et al., 2024), and data privacy (Lund & Wang, 2023). Although the above studies criticized the utilization of ChatGPT and other generative AI tools in educational settings, researchers and practitioners should not overlook the potential benefits that AI tools offer (Ellis & Slade, 2023). In this paper, our focus is on exploring the advantages of ChatGPT to assess its potential for enhancing the process of teaching and learning in statistics and data analytics.

2. Recent studies regarding the use of ChatGPT in teaching Statistics and Data Analytics

Statistics education is a critical component of various academic disciplines and real-world applications. However, students often encounter challenges in comprehending complex statistical concepts and their practical implications. ChatGPT is a robust chatbot endowed with the remarkable skill of converting technical terminology into easily comprehensible non-technical language, making it accessible to individuals without a technical background (Torabi & Syler, 2023).

In the context of online statistics and data science education, the use of a chatbot provides automatic and instantaneous responses to students' queries, like chatting with a course instructor. This leads to reduced workload for the instructor and more engaging learning experience for the students (Essel et al., 2022). The challenges and achievements in teaching online statistics courses have been studied from various aspects such as technology, classroom community, and student-content engagement (Flores et al., 2023). Since instructors and students become accustomed to online teaching in the post-pandemic era, how to effectively engage students with course content and stimulate student-instructor interaction plays an essential role in improving the quality of online teaching and learning.

Studies have documented the use of ChatGPT in business education and research. Cribben and Zeinali (2023) explored the use of ChatGPT in teaching management science, operations management, and data analytics. They demonstrated that ChatGPT helped students with understanding complex concepts, creating, and debugging code, and preparing for exam questions. ChatGPT also aided professors in designing courses, creating syllabi and content, and grading assignments. The authors highlighted the noticeable benefits of ChatGPT in writing and debugging code and aiding in grading. While ChatGPT offers the potential to improve teaching and learning, users should be aware of the limitations and drawbacks of ChatGPT as mentioned before. Similarly, Hassani & Silva (2023) revealed that ChatGPT allows data scientists to streamline different stages of their workflow including data cleaning, data preprocessing, model training, and results interpretation.

Ellis & Slade (2023) highlighted concerns regarding the use of ChatGPT and other generative AI tools in classrooms, including students' comprehension of statistical concepts, their ability to tackle complex problems, and integrity issues. On the other hand, the authors also delved into the possibilities of leveraging ChatGPT's capabilities in statistics and data science. Specifically, they provided examples of how ChatGPT can assist in crafting course

materials and offered recommendations on guiding students to engage with ChatGPT responsibly.

While previous studies have explored the potential of using AI tools to support courses in management science and data science, there has been limited research on the detailed and effective benefits students can gain from using ChatGPT in statistics and data analytics. This article aligns with this research trajectory, aiming to explore how students might benefit from ChatGPT in understanding fundamental concepts and honing analytical skills.

THE USE OF CHATGPT IN STATISTICS AND DATA ANALYTICS

There may be numerous applications of ChatGPT in the realm of statistics and data analytics. In this section, we provide only a few examples of how ChatGPT can be used in the learning and teaching of statistics and data analytics to engage students and enhance teaching. These examples include accessing relevant resources, predictive analytics, simulation, and customized ChatGPT. According to our firsthand experiences, students can use ChatGPT to clarify concepts, access relevant materials, generate code for various tasks, and receive step-by-step guidance on complex topics like hypothesis testing and regression analysis.

1. ChatGPT: Revolutionizing Educational Access and Content Generation in Modern Learning Environments

In some educational settings, there may be limited access to data sets, statistical software, or modern teaching resources, which can hinder the hands-on learning experience. In recent times, the adoption of chatbots by students has grown significantly, propelled by technological advances and the shift of education toward online and hybrid modalities. The emergence of ChatGPT has significantly changed the landscape by facilitating rapid and convenient access to information for students, despite the potential dangers and ethical concerns associated with its use (Okonkwo & Ade-Ibijola, 2021). ChatGPT allows instructors and students to create materials such as discussion topics, puzzles, prompts, and others (Shahriar & Hayawi, 2023). The swift access to information allows students to obtain pertinent content on specific subjects to better assist their studies. For instance, when asking ChatGPT to find resources relating to introductory to statistics in a specific manner, ChatGPT generated the output as shown in Table 1.

Table 1. *Teaching resources generated by ChatGPT*

Title	Description	Website
OpenIntro Statistics	This is a free online textbook designed for introductory statistics courses. It covers all the essential topics with clear explanations and real-world examples.	OpenIntro Statistics
Khan Academy - Statistics and Probability	Khan Academy offers a comprehensive set of video lectures and practice exercises on statistics and probability topics. It's a great resource for visual learners.	Khan Academy - Statistics and Probability

Title	Description	Website
Statistical Thinking for the 21st Century (ST21)	This free online course by Professor Mine Çetinkaya-Rundel from Duke University covers introductory statistics using the R programming language. It's available on Coursera.	ST21 on Coursera
Seeing Theory	This interactive website provides visual explanations of key statistical concepts. It's a great supplement to traditional textbooks and lectures.	Seeing Theory
Rice Virtual Lab in Statistics	This online resource from Rice University offers interactive applets that help you explore various statistical concepts. It's a great way to visualize and understand statistical principles.	Rice Virtual Lab in Statistics
CrossValidated	This is a question-and-answer site for statistics, data analysis, machine learning, and data visualization. You can ask your own questions or search for answers to common statistical queries.	CrossValidated
Statistics How To	This website provides easy-to-understand explanations and tutorials on various statistical concepts and procedures.	Statistics How To
Udacity - Intro to Statistics (With Python)	If you prefer learning through hands-on projects, this Udacity course introduces statistics using Python. It's suitable for beginners.	Udacity - Intro to Statistics (With Python)
MIT OpenCourseWare - Introduction to Probability and Statistics	MIT offers free lecture notes, assignments, and exams for their statistics course.	MIT OCW - Introduction to Probability and Statistics
DataCamp	This platform offers interactive courses on statistics and data analysis using R and Python. While some courses require a subscription, they often offer free trials.	DataCamp

Table 1 presents the relevant resources for introductory statistics that ChatGPT produced. We have checked each of the websites; they work and provide the relevant resources and materials. Students can access these websites to get what they need for their subjects. It is noticeable that the accessibility and adaptability of ChatGPT makes it an important asset in educational settings. This helps transform both teaching and learning in higher education, which helps prepare students for an AI-driven future.

2. Simplifying Complex Statistics: How ChatGPT Enhances Student Understanding of Theorems and Concepts

ChatGPT enables students to access to various resources and help them understand related materials. ChatGPT further helps in translating technical language into non-technical terms which can be easily comprehended for those without a technical background (Torabi & Syler, 2023). Moreover, ChatGPT offers diverse examples and practice opportunities to assist

students to get a better understanding of the underlying principles (Javaid et al.,2023). In the area of statistics and data analytics, students often struggle with understanding abstract concepts and mathematical calculations which prevent them from grasping the underlying principles. ChatGPT seems to have the potential to help students overcome these barriers.

To demonstrate how ChatGPT behaves in addressing queries related to statistical concepts, we crafted prompts that asked about the definition of a confidence interval and central limit theorem, and their corresponding applications. We structured these prompts in both professional and layman's terms. ChatGPT's responses to these prompts, which address concepts often deemed challenging by statistics learners, are presented in Table 2.

In the below example, ChatGPT provided detailed explanations of the basic concepts of confidence interval and the central limit theorem. More importantly, the application of confidence interval estimation and the central limit theorem undoubtedly helps students better grasp the concepts. However, users should always verify and validate the content generated by ChatGPT. Therefore, we should make students aware of the fact that ChatGPT may create fictional information or produce incorrect results. Students should be trained to use domain knowledge to assess whether ChatGPT provides accurate information or results.

Table 2. Prompts and ChatGPT responses

Prompt	ChatGPT response
Give the definition of a confidence interval	A confidence interval is a statistical range or interval estimate that provides a level of uncertainty around an estimated population parameter (such as a mean, proportion, or regression coefficient) based on a sample from the population. It is calculated from sample data and indicates the likely range within which the true population parameter is expected to lie with a certain level of confidence.
Give the definition of a confidence interval using non-technical languages	In simple terms, a confidence interval is like a "range of possibilities" that we calculate using sample data from a larger group (population). It helps us estimate where the true value of something we're interested in, like an average or a proportion, might be within that range.
Interpret a 90 % confidence interval for a population mean	The 90% confidence level means that if you were to take many random samples from the same population and calculate a 90% confidence interval for each sample, about 90 out of 100 of these intervals would contain the true population mean. In other words, it's a measure of how confident you are that the true mean falls within the calculated interval.
Interpret a 90 % confidence interval for a population mean(practical interpretation)	Suppose you are conducting a survey to estimate the average income of households in a city. After collecting and analyzing a random sample of data, you calculate a 90% confidence interval for the population mean income, which results in a range of \$40,000 to \$45,000. Interpretation: You can say with 90% confidence that the true average income of households in the city is somewhere between \$40,000 and \$45,000.
Give a definition of the central limit theorem	The Central Limit Theorem (CLT) is a fundamental concept in statistics that states that, regardless of the shape of the original population distribution, the sampling distribution of the sample mean approaches a normal distribution as the sample size increases. In other words, as we take larger and larger random samples from a population and calculate the means of those samples, the distribution of those sample means will tend to follow a bell-shaped curve known as the normal distribution.

Prompt	ChatGPT response
Give a definition of the central limit theorem using non-technical language	<p>Sure! The Central Limit Theorem (CLT) is a powerful idea in statistics that tells us something very useful. It says that if we take lots of random samples from any population, no matter what shape it has, and calculate the average of each sample, those sample averages will tend to follow a nice, predictable, bell-shaped curve called the normal distribution.</p>
Give an application of the central limit theorem.	<p>One common and practical application of the Central Limit Theorem (CLT) is in hypothesis testing and confidence interval estimation, particularly when dealing with real-world data that may not follow a perfect normal distribution. Here's an example:</p> <p>Application: Examining the Average Test Scores</p> <p>Suppose you're an educator interested in assessing the performance of students in a large school district. You want to determine whether the average test scores of students in this district have improved over the years. To do this, you collect test score data from a random sample of 200 students each year for the past 10 years. Each year's test scores may come from different schools, grade levels, and subjects, resulting in a wide variety of score distributions.</p> <p>Here's how the Central Limit Theorem is applied in this scenario:</p> <ol style="list-style-type: none"> 1. Sampling: You randomly select 200 students from each year's data, ensuring that each sample is independent and identically distributed (i.e., the scores in each sample come from the same population with the same distribution). 2. Calculate Sample Means: For each year, you calculate the mean test score for the 200 selected students. 3. CLT Application: According to the Central Limit Theorem, the distribution of sample means from each year will tend to follow a normal distribution, even if the original test score distributions were not normal. 4. Hypothesis Testing: You can then perform hypothesis testing to compare the average test scores over the years. For example, you might want to test whether there has been a statistically significant improvement in average test scores. 5. Confidence Intervals: You can also calculate confidence intervals for each year's average test score to estimate the range within which the true population mean might lie with a certain level of confidence. <p>By applying the Central Limit Theorem, you can confidently use statistical methods and hypothesis tests that assume a normal distribution of sample means, even if the individual test score distributions in each year were not normal. This allows you to draw meaningful conclusions about the overall performance trends in the school district, despite the variability in the data sources and distributions.</p>

3. Predictive Analytics

As a text-based language model, ChatGPT excels at understanding and generating human-like text in response to user prompts. Its primary function is natural language processing. However, ChatGPT has also risen as a highly promising technology in the field of data

analytics, bringing with it the benefits of accelerated analysis, deeper insights, personalized experiences, and cost-effectiveness in different business sectors (Kumar et al., 2023). ChatGPT is reshaping our approach to data analytics. Recently, ChatGPT4 allows users to install data analysis plugin, enabling users to upload data into ChatGPT for further data analysis. With the aid of the data analysis plugin, ChatGPT can help with tasks similar to those performed by a data scientist, including data cleaning, feature engineering, generating graphs, and performing various data analyses. During this process, ChatGPT also provides step by step guidance and detailed explanations.

In the following example, we used a small dataset: Rent from Levine's text (Levine et al., 2016) to show how ChatGPT assist in conducting a simple linear regression analysis. We first set the context, and then asked ChatGPT to act as a data scientist with 15 years of experience in the field. We further prompted it to generate a data dictionary. Once we checked the data type and verified that ChatGPT obtained the correct data, we requested ChatGPT to produce a scatter plot and calculate the correlation coefficient. As depicted in Figure 1, ChatGPT successfully generated a scatter plot and accurately determined the correlation coefficient. The plot suggests a positive linear relationship between the apartment size and its monthly rent. Furthermore, the association between these two numerical variables appears strong. Consequently, we proceeded to request ChatGPT to perform a simple linear regression analysis, considering the rent as the dependent variable and size as the independent variable. Once again, ChatGPT produced accurate results and provided detailed explanations. The prompts and ChatGPT response were provided as follows:

Prompt1: you are a seasoned data analyst with 15 years of experience and cutting-edge knowledge of all the tools and techniques.

Prompt 2: Please generate data dictionary about the data provided.

Prompt 3: Please create a scatter plot and calculate correlation coefficient between the two variables.

ChatGPT Responses: "The correlation coefficient between the variables 'Size(X)' and 'Rent(Y)' is approximately 0.8501. This indicates a strong positive linear relationship between the size of the property and the rent amount. As the size increases, the rent also tends to increase."

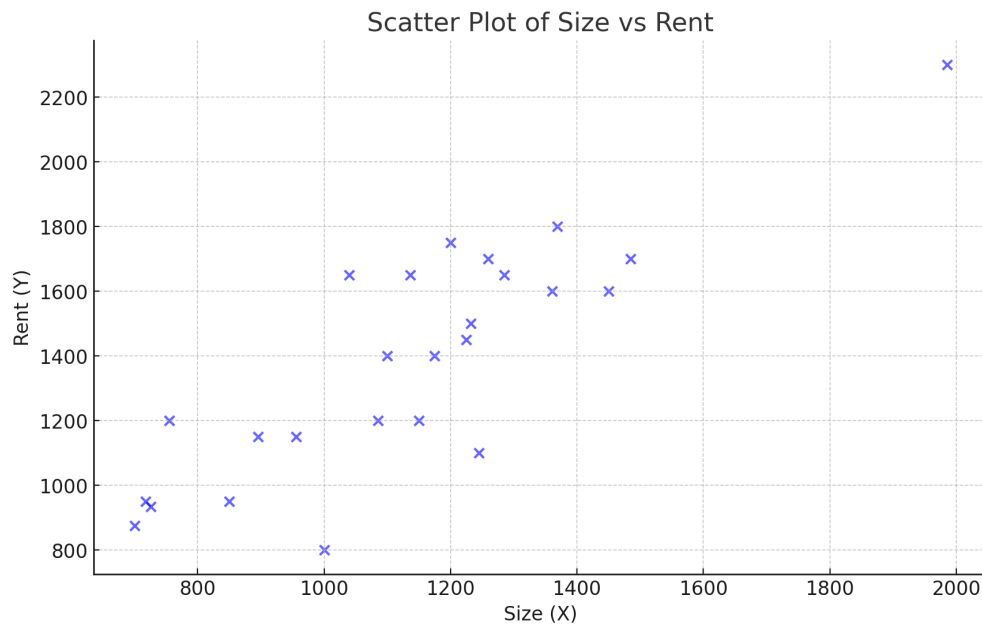


Figure 1. Scatter plot of size vs rent

Prompt 4: Please conduct simple linear regression analysis, using size as an independent variable and rent as a dependent variable.

ChatGPT response: “The results from the simple linear regression analysis using 'Size(X)' as the independent variable and 'Rent(Y)' as the dependent variable are as follows:

1. Equation of the Regression Line: $\text{Rent}(Y) = 1.0651 \times \text{Size}(X) + 177.1208$
2. Slope (Coefficient for Size): 1.0651
 - This indicates that for every unit increase in Size (X), the Rent (Y) increases by approximately \$1.0651, assuming all other factors remain constant.
3. Intercept: 177.1208
 - This is the estimated Rent (Y) when Size (X) is 0. However, it's essential to interpret this with caution as having a property size of 0 may not be practical.
4. R-squared: 0.7226
 - The R-squared value indicates that approximately 72.26% of the variance in Rent can be explained by the Size.
5. Mean Squared Error (MSE): 34837.9782
 - The MSE provides a measure of how well the model fits the data. A lower MSE indicates a better fit.

The positive slope indicates a direct relationship between Size and Rent: as the size of the property increases, the rent also tends to increase.”

In Figure 1, the scatter plot reveals a relatively strong association between size and rent. As a result, we can proceed to conduct a simple linear regression analysis. ChatGPT subsequently produced the results based on the given prompt, providing comprehensive details about the regression model, regression coefficients, R-squared value, and Mean Squared Error, accompanied by their respective explanations. The data analysis capability of ChatGPT is invaluable for students who are struggling with analyzing data. In disciplines such as statistics and data analytics, where students consistently engage in data analysis, ChatGPT proves to be helpful as it provides a step-by-step guide on how to approach specific problems.

Kumar et al. (2023) claim that the convergence of data analysis and ChatGPT occurs at the crossroads of Natural Language Processing (NLP) and Machine Learning. ChatGPT has demonstrated substantial potential across a range of applications, including data analytics. Furthermore, ChatGPT has exhibited promise in areas such as data visualization, descriptive analytics, pattern recognition, sentiment analysis, and beyond. In this section, we have only presented an example of predictive analytics performed by ChatGPT. However, there are other applications of ChatGPT in data analytics that deserve greater attention.

4. Code Generation and Simulation

Modern statistics has transformed into a predominantly computational science (Cobb, 2015). Key concepts in current statistics are often best understood through computational data analysis methods (Tucker et al., 2022). For example, programming language R is a statistical computing environment used for data analysis and has been widely adopted by scholars and professionals in STEM fields. Many instructors have noted that students often hate programming and are concerned that students' initial apprehensions towards programming languages such as R and Python might deter them from engaging with statistics (Rode & Ringel, 2019; Tucker et al. 2022). In the future, coding will be a new form of literacy, with the expectation that students in the 21st century will acquire this skill. ChatGPT facilitates this learning process by generating code in various programming languages such as Python and R in response to user prompts, enabling users to execute it in their preferred software (Gribben & Zeinali, 2023).

Simulation also plays an essential role in teaching statistics and data analytics. Researchers and practitioners have used simulation methods to solve real world problems. Through

simulation, users can visualize abstract concepts and theorems, and test hypotheses about data, thereby improve their understanding of statistical concepts and procedures. To gain a better understanding of the meaning of a sampling distribution and the central limit theorem, we can use ChatGPT to simulate the central limit theorem. Mills (2002) argued that clarifying these statistical concepts using simulation methods early in the course can be beneficial to statistical concepts introduced later. To achieve this, students can craft simple prompts and feed them to ChatGPT, which then generates Python scripts for simulations.

When prompted to simulate the central limit theorem, ChatGPT generated the following responses: “The Central Limit Theorem (CLT) is a fundamental theorem in probability and statistics that states that the distribution of the sum (or average) of many independent, identically distributed random variables approaches a normal (Gaussian) distribution, regardless of the shape of the original distribution.

To demonstrate the Central Limit Theorem, we can follow these steps:

1. Choose a non-normal distribution (e.g., uniform, exponential, binomial, etc.).
2. Randomly sample n values from the distribution multiple times (e.g., 1000 times).
3. Calculate the average of each sample.
4. Plot the distribution of the sample averages.

The distribution of these averages will approach a normal distribution as n (the sample size) increases. Which distribution would you like to start with, and what sample size n would you like to use for demonstration?”

Below is the python code that ChatGPT generated:

```

“import numpy as np
import matplotlib.pyplot as plt
def central_limit_theorem_demo(population_size=10000, sample_size=30,
num_samples=1000):
    # Create a population with a uniform distribution
    population = np.random.uniform(0, 1, population_size)
    # Draw samples and compute means
    sample_means = [np.mean(np.random.choice(population, sample_size)) for _ in
range(num_samples)]
    # Plot the sampling distribution of the sample mean
    plt.hist(sample_means, bins=50, density=True, alpha=0.7, color='blue')
    plt.title('Sampling Distribution of the Sample Mean')
    plt.xlabel('Sample Mean')
    plt.ylabel('Frequency')
    plt.show()
central_limit_theorem_demo()

```

This code will generate a histogram that shows the sampling distribution of the sample mean. As you can see, even though we're sampling from a uniform distribution, the sampling distribution of the sample mean tends towards a normal distribution due to the Central Limit Theorem. You can adjust `population_size`, `sample_size`, and `num_samples` as needed.”

As shown in Figure 2, the distribution of these sample averages is roughly normal, demonstrating the Central Limit Theorem. The histogram's shape mirrors the bell curve of a normal distribution, even though the initial data came from a non-normal (uniform) distribution. This aligns with the Central Limit Theorem's predictions.

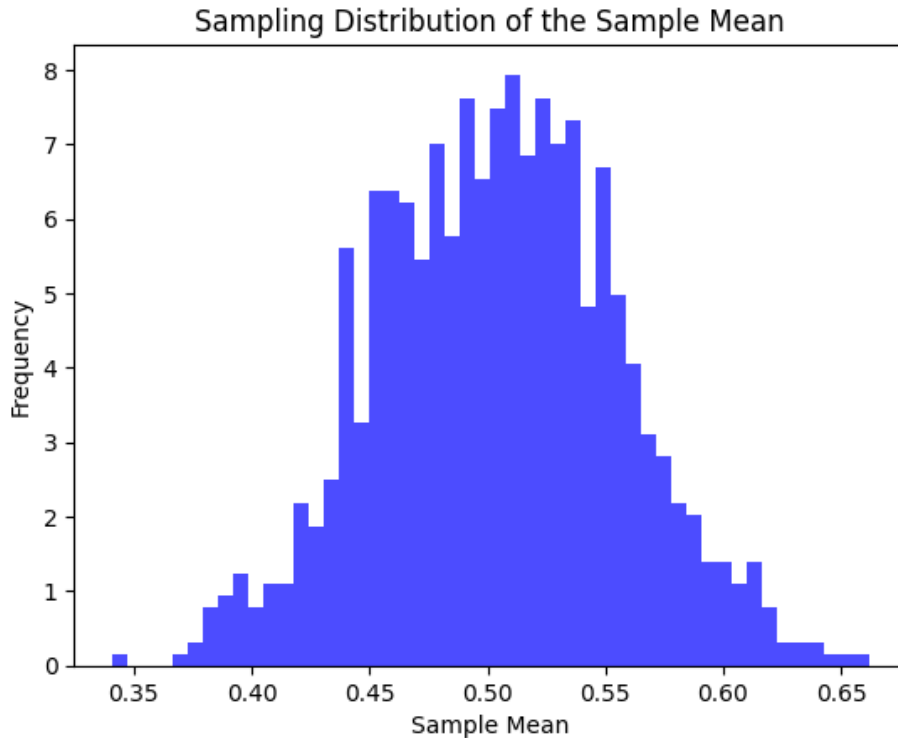


Figure 2. Sampling distribution of sample mean based on uniform distribution.

We further prompted ChatGPT to explain each line of code. “Of course! Let's break down the code step-by-step.”

The screenshot shows a chat interface with a dark background. At the top, there is a code block with the following Python code:

```
python
import numpy as np
import matplotlib.pyplot as plt
```

Below the code, the text reads: "Here, we're importing the necessary libraries. We'll use 'numpy' for numerical operations and random number generation, and 'matplotlib.pyplot' for plotting the results."

Underneath, there is a section titled "1. Defining the Central Limit Theorem Demo Function:" followed by another code block:

```
python
def central_limit_theorem_demo(population_size=10000, sample_size=30, num_sa
```

Figure 3. Screenshot showing part of code explanations by ChatGPT

Figure 3 shows ChatGPT’s explanations about the meaning and the purpose of the Python code. After ChatGPT explained each line of code in the simulation process, we could ask student to change the probability distribution to standard normal distribution with a mean of 0 and standard deviation of 1 and $n=25$, execute the code again. As shown in Figure 4, the histogram indicates a normal distribution too. Students can also modify the `population_size`, `sample_size`, and `num_samples` variables and then execute the Python code. By going through this process, students not only enhance their programming skills but also gain a deeper understanding of the central limit theorem.

The example demonstrated the potential benefits of ChatGPT using simulation to aid students' learning in statistics and data analytics courses. It also proves that ChatGPT can be used to help students with their programming courses. That is, students don't need to begin by writing code from scratch. Instead, they can initially request ChatGPT to generate scripts for their tasks and then modify the code through multiple interactions with ChatGPT to complete the tasks. From a student's perspective, it is beneficial for those students without coding experience or those just beginning their coding journey. Moreover, it helps students with strong programming skills to improve their productivity. From a faculty's viewpoint, ChatGPT provides instructors with the opportunity to assign more open-ended tasks, encouraging students to collaborate with AI in generating code and then refining it until it is both accurate and efficient. In the classroom, instructors may emphasize on code reading and critique rather than code-writing. Clearly, a foundational knowledge of the subject is vital to effectively leverage ChatGPT for teaching and learning. Although ChatGPT can quickly produce sophisticated code, it should not be considered a substitute for advanced problem-solving abilities. That is, students still need to understand the dataset and the objective of the data analysis so that they can further carry out more advanced analyses.

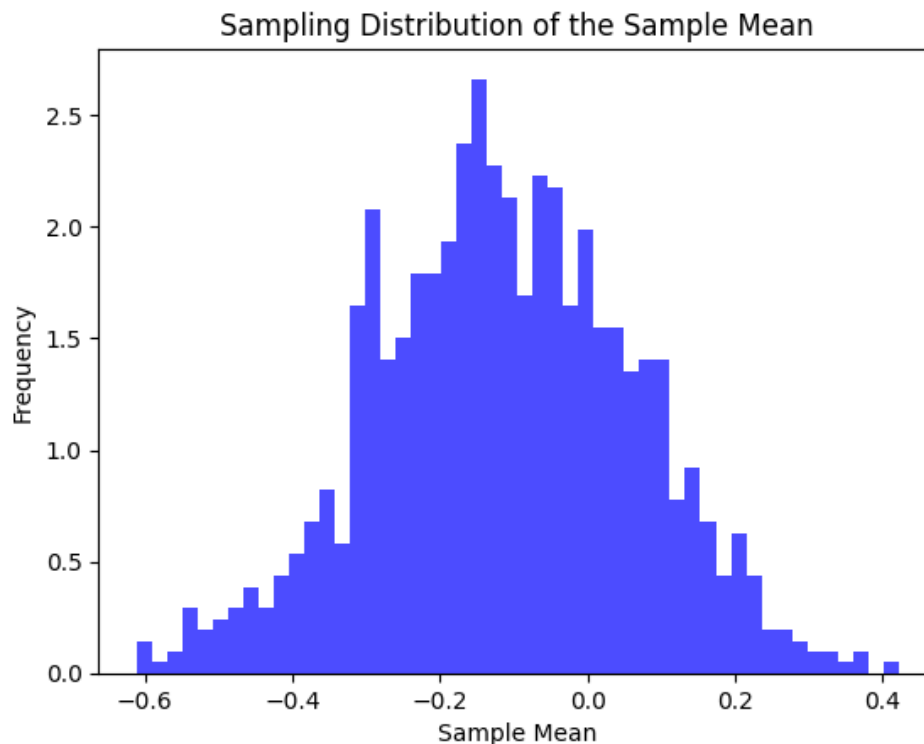


Figure 4. Sampling distribution of the sample mean based on standard normal distribution and $n=25$.

5. Customized GPT

Recently, ChatGPT enables users to create custom versions tailored to specific needs. Educators can create their own GPT by combining domain knowledge and skills in their fields to promote personalized learning. Teaching the concept of inferential statistics can be challenging for statistics instructors because students often struggle to make logical connections between inferential statistics and other aspects of statistics, such as descriptive statistics and probability (Park, 2019). With the recent development of ChatGPT 4, we now have the capability to create a Chatbot that can serve as Stat Coach, helping students gain a

better understanding of the concept of hypothesis testing and its process. To create a customized GPT, the GPT Builder first prompts users to answer questions, users can make changes if they are not satisfied with the results, such as the name of the GPT and its functionalities. The GPT's behavior gets updated accordingly once the builder receives users' responses. We created a Stats Coach and conducted tests on it by asking for the definition of hypothesis testing and an example of one-sample Z-test. The Stat Coach generated the response as follows:

"Stats Coach is almost ready! Here's a summary of its behavior:

- **Role & Goal:** A friendly guide for students in statistics, focusing on hypothesis testing. It simplifies complex concepts and guides users through statistical processes.
- **Style:** Casual, friendly, and supportive, making statistics approachable.
- **Interaction:** Encourages independent problem-solving, asks for clarification on unclear queries, and avoids providing direct answers.
- **Limitations:** Stays away from overly complex or advanced statistical topics not typical in standard coursework."

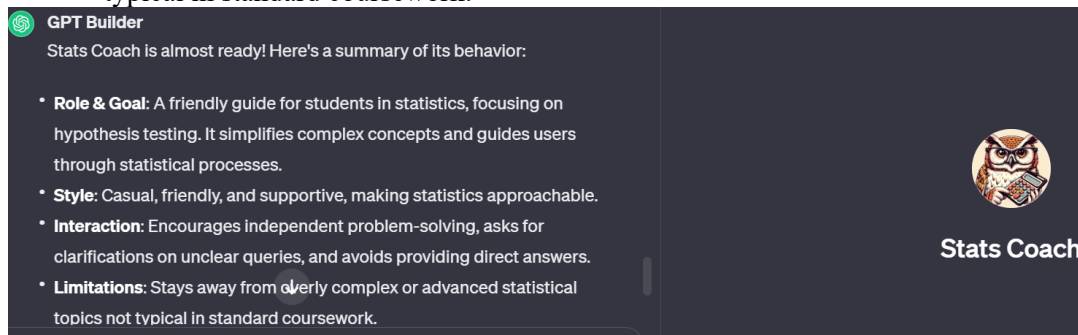


Figure 5. Screenshot showing Stats Coach.

We then asked the Stats coach to define hypothesis testing. The Stats coach produced the following responses:

"Hypothesis testing is a fundamental concept in statistics used to determine if there's enough evidence in a sample of data to support a particular belief (or hypothesis) about a population parameter. Here's a simple breakdown of how it works:

1. **Formulating Hypotheses:** You start by stating two hypotheses. The null hypothesis (H_0) usually represents the status quo or a statement of no effect, and the alternative hypothesis (H_1) represents what you want to test or prove.
 - For example, if you're testing a new drug, H_0 might be "The drug has no effect on the disease," while H_1 could be "The drug has a positive effect on the disease."
2. **Choosing a Test:** Depending on your data and what you're testing (means, proportions, etc.), you select an appropriate statistical test (like a t-test, chi-square test, etc.).
3. **Collecting Data:** Gather the data you need for your test. This could be through experiments, surveys, observations, etc.
4. **Performing the Test:** Conduct the statistical test which will give you a test statistic and a p-value.
5. **Making a Decision:**
 - The p-value is key here. It tells you how likely it is to get a result like yours if H_0 is true.
 - If the p-value is low (typically less than 0.05), it means your result is rare under H_0 , so you reject H_0 in favor of H_1 .
 - If the p-value is high, you don't have enough evidence to reject H_0 .

6. **Interpreting Results:** Finally, you interpret the results in the context of your research question. Remember, rejecting H_0 doesn't prove H_1 is true; it just means there's enough evidence to support it.

Hypothesis testing is a structured way to make decisions and draw conclusions from data, and it's widely used in many fields like medicine, psychology, economics, and more. It's like a formal process for seeing if the evidence backs up your theories or assumptions!"

As shown in Figure 5, it presents the chatbot's functionalities so that users understand what they can interact with the customized GPT, and Figure 6 shows an example of a one-sample Z-test. It appears that the Stats Coach clearly explained the concepts of hypothesis testing and its process. We then requested an example of a One-Sample Z-test, and the Stats Coach quickly generated an example, as shown in Figure 6, and solved the problem correctly by following the hypothesis process detailed in the responses from our first request.

Stats Coach ▾

Hypothetical Scenario

Imagine you're examining the effectiveness of a new tutoring program on student test scores. Let's say the national average score for a standardized test is 70 (this is our population mean, μ). You want to know if the students who went through your program score differently on average.

Data

- **Population Mean (μ):** 70
- **Sample Mean (\bar{x}):** Let's say the average score of 30 students who took your program is 73.
- **Population Standard Deviation (σ):** Assume it's known and is 8. (In real-world scenarios, this might not be known and you'd use a t-test instead.)
- **Sample Size (n):** 30 students
- **Significance Level (α):** 0.05 (common choice)

Figure 6. Screenshot showing an example of a Z-test.

The Stats Coach behaves as expected, explaining everything in a detailed and friendly manner, just as we anticipated. It shows that customized chatbots undoubtedly engage students and enhance student-content interactions. It is more valuable when human tutors and instructors are not available. This will contribute to addressing the challenges mentioned in Section I.

DISCUSSIONS

While ChatGPT can be a valuable tool for learning and teaching, users should not rely solely on it as their only source of knowledge. It's essential to always verify the information that ChatGPT provides. When studying statistics and data analytics, learners must employ domain knowledge to identify any inaccuracies or biased responses. This perspective aligns with Javaid et al. (2023), who emphasized the importance of diversifying sources and using ChatGPT as a supplement to traditional learning materials.

To fully harness the benefits of using ChatGPT in teaching and learning statistics and data analytics, users should hone their skills in crafting effective prompts. The ability to generate well-phrased prompts is crucial for leveraging ChatGPT's full potential. Generally, ChatGPT might produce varied responses with similar content based on the same prompt. Within the realm of statistics and data analytics, while the numerical results should remain consistent, the phrasing of ChatGPT's responses may differ. Although ChatGPT can execute a wide range of tasks, mastering its full capabilities requires users to develop specific skills. This includes not only crafting prompts adeptly but also evaluating the generated output

critically. Courses in "prompt engineering" would be beneficial for students to form effective prompts and thereby optimizing their use of ChatGPT.

The emergence of ChatGPT undoubtedly presents new challenges and threats to education (Lo, 2023). Despite concerns about using ChatGPT in educational settings, its integration into statistics and data analytics instruction shows promising potential for future advancements. As AI technologies progress, models such as ChatGPT could enhance their contextual awareness, offering even more personalized and effective learning experiences. Consequently, the promotion of ChatGPT in educational settings is advisable, and students should be encouraged to engage with ChatGPT in a responsible manner.

CONCLUSION

This paper examines the potential of integrating ChatGPT into the teaching of statistics and data analytics courses. We provided detailed examples from our own use, which includes various applications of ChatGPT, ranging from accessing extensive course materials and translating intricate concepts into layman's terms, to requesting ChatGPT to generate Python code for predictive analytics and simulation. More importantly, users of ChatGPT4 can now create customized GPTs to meet their specific needs, which greatly helps overcome the barriers of learning and teaching in statistics and data analytics. Thus, ChatGPT has the potential to positively impact students' academic performance and assist them in developing programming and analytical skills, which in turn enhance their job prospects.

While the article did not employ experimental research methods, it highlights ways in which instructors might integrate ChatGPT into their teaching approaches to help students overcome challenges in learning statistics and data analytics. As advancements in AI technology persist, educators may harness the power of AI-driven tools to enrich students' experiences, deepen their understanding of complex materials, and help them develop analytical skills since tailored ChatGPT chatbots provide individualized, engaging, and context-aware learning experiences. Nevertheless, it's critical to address the ethical considerations and challenges associated with data privacy and biases, ensuring a responsible and fair deployment.

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