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The impact of ChatGPT-based learning statistics on undergraduates' statistical reasoning and attitudes toward statistics

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Abstract

Today, artificial intelligence (AI) has become a major factor in driving sustainable development. AI technology facilitate the innovation and creativity that could be used to achieved the sustainable development goals SDG, where education is the third SDG. Since the emergence of an advanced language model supported by AI, ChatGPT has been widely used in various fields, including education. Perhaps the fields of mathematics in general and statistics, in particular, are among the most important. Therefore, this study was conducted to investigate the impact of ChatGPT-based learning on statistical reasoning and attitudes towards statistics among undergraduates. The study followed a quasi-experimental design. To achieve their objectives, the researchers employed two valid and reliable assessments: the statistical reasoning assessment and the attitude toward statistics measure. The study sample included 56 students from the Arab Open University in Jordan and was distributed into two groups: experimental and control. The results demonstrated the effectiveness of using ChatGPT in developing statistical reasoning and fostering positive attitudes towards statistics. These findings encourage statistics instructors to incorporate ChatGPT into their teaching methods and motivate students to utilize it in their learning of statistics.

Keywords: ChatGPT, statistics, undergraduates, statistical reasoning, attitudes toward statistics

INTRODUCTION

Mathematics plays a significant role in various fields of learning, and the last two decades have witnessed a shift in the objectives of mathematics education from developing the cognitive aspect to the necessity of acquiring thinking methods capable of employing mathematical knowledge in solving various problems (Quttina & Al-Sharaa, 2020). This is evident through its multiple applications in all scientific and life fields, especially the field of applied mathematics, where statistics is the most prominent of these domains (Al-Barakat et al., 2022). Statistics is one of the branches of mathematics that is mainly concerned with collecting data, presenting it in tables, making graphical representations of mathematical data, and finding appropriate measures (Bukhatwa et al.,2023). Because of its importance, statistics has been included in educational programs in universities and considered one of the compulsory and basic courses with the aim of providing students with skills that enable them to employ aspects of statistics in their scientific and professional lives (Saddam, 2020). Despite the importance of statistics in daily life, such as analyzing data, reaching conclusions, developing appropriate solutions, and making future decisions, many students have difficulty understanding statistics (Atwan, 2015¸ Chan & Ismail, 2013). In line with this, Koparan (2015) pointed out some difficulties in studying and teaching statistics, encompassing tasks such as the difficulty of statistical rules and students' feelings of anxiety due to the large amount of dealing with data that requires different interpretations and specialized skills, as Shtayyeh and Al-Sharaa (2022) confirmed the belief of university students in the difficulty and complexity of mathematics, which explain the poor performance of Jordanian students in the results of the international study TIMSS, where the results showed the low performance of students in the field of data and

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Contribution to the literature

- This study examines the impact of one of the most popular applications of artificial intelligence on learning statistics within the field of mathematics education.
- This study adds to the limited literature on development Statistical reasoning skills among university students.
- This study focused on non-cognitive aspects represented by attitude towards learning statistics and adding a new approach to its development by exploiting the capabilities of artificial intelligence.

probability (statistics). Furthermore, there is weakness and lack of interest in teaching statistics in general in the Arab world (Hijazi & Alfaki, 2020), various studies recommend the necessity of directing and integrating efforts to develop statistical skills (Abdel-Naim, 2020).

Statistical reasoning is defined as the ability to interpret statistical concepts, processes, and results, identify relationships between them, and provide rationale for their use (Al-Ganaam, 2018), and is considered the most crucial statistical skill that concerns the student's way of thinking about statistical ideas and understanding statistical information (Rohana & Ningsih, 2020). Therefore, students who have more reasoning skills achieve learning goals faster and with higher efficiency (Hasanah et al., 2018). Gal and Ginsburg (1994) highlighted non-cognitive elements in learning statistics, such as attitudes, as being influential in the process of students learning statistics. Attitudes can have a good impact by motivating individuals to pursue specific goals. Conversely, attitudes can also have a negative impact (Al-Balwi & Al-Shamari, 2023). Hence, Bromage et al. (2022) confirm that many of the key challenges to statistics learning and teaching come from negative attitudes towards them.

Despite the significance of statistical reasoning and considering it an indispensable learning goal that instructors aim to teach to their students (Sabbag et al., 2018) and the significance of attitudes towards statistics in student learning, the results of the studies indicate a low level of statistical thinking among students (Chana et al., 2013) and a dominance of negative attitudes over their beliefs towards this subject (Shtayyeh & Al-Sharaa, 2022). Therefore, some studies explained the importance of technology in understanding statistical ideas, with emphasis on the need for effective planning to merge technology into the statistics learning process (Ausat et al., 2023; Chance et al., 2007). Recent trends in education have indicated that the more artificial intelligence (AI) applications are used, the greater the opportunities to develop and improve the educational system (Mokhtar, 2020).

Perhaps the most prominent and latest of these technologies is ChatGPT. It is a conversational AI interface developed by OpenAI as a generative model; it can generate new text based on the input it receives (Hassani & Silva, 2023; Hill-Yardin, et al., 2023). The advantages of ChatGPT have been used in various sectors, especially the educational sector, ChatGPT, with its advantages and characteristics, can help the educational sector in many ways (Biswas, 2023; Shidiq, 2023). Perhaps one of the educational sectors is the mathematics education sector, where Supriyadi and Kuncoro (2023) mention that mathematics teaching will see the integration of technology and AI, which aims to personalize the mathematics learning experience and develop necessary skills. Therefore, some studies explained the importance of technology in understanding statistical ideas with emphasis on the need for effective planning to merge technology in the statistics learning process (Ausat et al., 2023; Chance et al., 2007). Perhaps the most prominent and latest of these technologies is ChatGPT. It is a conversational AI interface developed by OpenAI as a generative model; it can generate new text based on the input it receives (Hassani & Silva, 2023; Hill-Yardin, et al., 2023). The advantages of ChatGPT have been used in various sectors, especially the educational sector, ChatGPT, with its advantages and characteristics, can help the educational sector in many ways (Biswas, 2023; Shidiq, 2023). Perhaps one of the educational sectors is the mathematics education sector, where Supriyadi and Kuncoro (2023) mention that mathematics teaching will see the integration of technology and AI, which aims to personalize the mathematics learning experience and develop necessary skills.

According to the above, this quasi-experimental study evaluates the influence of ChatGPT-based learning in the context of statistics learning. It specifically examines the effects on statistical reasoning and attitudes towards statistics among undergraduate students. The forthcoming section of this paper will present the literature review, then the research methodology followed by the findings and discussion section and finally the conclusion, that summarizing findings, providing recommendations, acknowledging limitations, and identifying avenues for future research.

A LITERATURE REVIEW & THEORETICAL FRAMEWORK

Learning Statistics

Statistics is considered one of the most important and prominent disciplines as a stand-alone discipline, not an appendage to mathematics education (Garfield &

Ben-Zvi, 2007). Statistics can be defined as a branch of applied mathematics that includes theories and methods oriented towards collecting and describing data, extrapolation, and decision-making (Zayed, 2007). According to Moreno (1998), the concepts of statistics arose based on the probability theory, and they are divided in two main branches: mathematical statistics and applied statistics, which are also divided in descriptive statistics and inferential statistics. (Abdel-Gawad, 2021). In addition, statistics play a prominent role in developing future plans by predicting phenomena through various statistical analyses (Abdel-Barr, 2016). Therefore, based on the important role of statistics Rohana and Ningsih (2020) emphasize the importance of teaching statistics to students, while Al-Sarhani (2023) mentions the importance of statistics education to develop students' skills and competencies to manage their academic and professional lives in the digital age. In the same context, Ben-Zvi and Makar (2016) state that teaching statistics is an important field for students' skills, because there are many events in real-world contexts that require statistical knowledge and skills to allow them to interpret and analyze data to obtain a clear view of many phenomena.

Based on the above, several studies have been conducted that focused on improving students' learning of statistics. Mubarak's (2015) study confirmed the need to focus on practical applications in teaching mathematics and statistics and use modern educational methods that employ technology in learning statistics, involve students in the lesson, and teach them to think, such as using different statistical programs such as Excel and statistical package for the social sciences (SPSS) while the Gehrke et al. (2021) study focused on teaching data-centric statistics in tertiary education via rethinking the curriculum with a strong emphasis on the data-generating process within the scientific inquiry. The study by Novak et al. (2016) explored developing statistical skills through a storyline gaming characteristic, and the results offer future directions for embedding these approaches in statistic learning content. In the context of focusing on technology in teaching statistics, Al-Rawahi (2017) emphasized the effectiveness of using the Web Quest in developing statistical problem-solving skills among tenth-grade students in Oman, while Suleiman (2019) confirmed the effectiveness of the flipped classroom in developing statistical analysis skills for students in Egypt, while the study of Seebut et al. (2023) aimed to use ChatGPT and Google Colab to find numerical solutions to mathematical equations, as the study demonstrated the ability of these applications to provide students with the ability to find numerical solutions to differential equations, with a high level of self-efficacy among the students, and thus work on using these two tools to solve problems.

Statistical Reasoning

Statistical reasoning is considered part of many disciplines. Sariningsih and Herdiman (2017) defined statistical reasoning as a form of reasoning closely related to probability numbers, which are used in the process of Results and making decisions in situations, which cannot be expressed from probability perspective. According to Rufiana et al., (2019), there are five statistical reasoning levels: Level 1: Idiosyncratic in which students can use several statistical symbols but cannot fully understand appropriate information. In level 2 verbal, students find the definitions of some statistical ideas, but fail to apply them correctly. Level 3 transitional: Students can recognize a few aspects of the statistical process but cannot include some concepts to answer questions. Level 4 procedural, students can identify statistical processes accurately, but are still weak in their ability to fully understand and are unable to integrate them, but in level 5 integrated processes students have full knowledge of the statistical process and can integrate it. Therefore, Gaviria-Bedoya et al. (2022) argue that statistical reasoning is important for students who take statistical courses because they can develop abstract reasoning processes and identify patterns to make inferences and provide conclusions beyond the data.

Despite achieving good grades in statistics-courses, previous studies revealed students still performed poorly in statistical reasoning (Garfield, 1998; Tempelaar, 2004). For that, Biehler et al. (2013) suggested a future direction for using technology in developing students' statistical reasoning, which contains various technological tools to support the teaching of statistics, such as statistical software packages, spreadsheets, applications, multimedia materials, and educational software. Also, a literature review indicates the efficiency of the use of technologies in developing students' statistical reasoning. According to Lawson et al. (2003), extensive use of application technology in the development of statistical reasoning among students, and in a recent study by Ramadhani and Evans (2022), which involved 55 participants from engineering students, the results showed the effectiveness of using a flipped classroom model with SPSS and STATCAL applications in development and enhanced the statistical reasoning abilities of students.

Attitudes Towards Statistics in Context of ABC Model

Generally, attitudes play a major and decisive role in guiding the behavior of the individual and helping him to adapt and achieve personal and social compatibility (Al-Maaita, 2007). Eagly and Shelly (2007) defined attitude as psychological tendencies, represented by the amount of preference or lack of preference for something or a person, as these tendencies are formed based on the individual's personal assessment. Accordingly, the

attitude has several overlapping components: a cognitive component, which are beliefs about some judgments related to the stimulus; emotional components, which are emotional responses towards a stimulus; these responses may be positive, negative, or neutral; and finally, behavioral components, which are the individual's behavioral methods or individual behavioral tendencies towards a particular stimulus (Sabah & Abu Aqil, 2015). These three components constitute the ABC attitude model, also known as a tripartite model. This model of attitude is based on a hierarchical model described by Ajzen (1993), who conceptualizes an attitude as an amalgamation of three distinct measurable parts (Mazana et al., 2019), which are; affective, behavioral and cognitive components. Also, attitudes are acquired and affected by a range of factors, such as motivation, which is the internal force that stimulates the behavior of the individual, the new needs that appear in the environment of the individual, the learning process itself, and the position that the individual is exposed to (Farooq & Shah, 2008). Given the importance of attitudes, psychologists developed qualitative methods of assessing the beliefs that underlie attitudes (Fishman et al., 2021).

Attitude towards statistics is defined as feelings that result from experiences encountered by students while learning statistics over a period of time. Whether these experiences are positive or negative (Martins et al., 2011), hence, many studies have focused on attitudes towards statistics, factors influencing their formation, and the methods that can be followed in modifying them or forming new desirable attitudes (Youssef & Al-Shayeb, 2018). Bromage et al. (2022) confirmed that the biggest obstacles to learning statistics stem from psychological aspects such as low motivation and negative attitudes towards learning it, so developing positive attitudes in statistics students is an implicit objective in statistics courses. Therefore, Judi et al. (2011) suggested that statistics courses require active methods of teaching them. Ghulami et al. (2015) confirmed the importance of teachers in enhancing students' positive attitudes towards statistics by improving their thinking skills in statistics and using statistical knowledge to solve daily problems. However, in the context of ABC model of attitude the Attitude towards statistics involves the affective, behavioral, and cognitive components, which collectively influence individuals' emotional responses, behaviors, and beliefs towards the statistics subject.

A literature review indicates the importance of employing technology in developing attitudes toward learning mathematics in general. Higgins et al. (2019) state the effectiveness of using technology to stimulate motivation and attitude toward learning mathematics. While Demir and Onal's (2021) confirmed the effectiveness of technology-assisted learning on students' attitudes toward mathematics and their academic achievements, in particular, literature has shown the importance of students' attitudes toward statistics, especially those of university-level students who specialize in scientific colleges (Gundlach et al., 2015). In addition, attitudes toward statistics play a vital role in statistical understanding (Showalter, 2021). Notably, experimental studies that show the impact of technology on developing attitudes towards learning statistics focus on statistical packages. Jatnika (2015) investigates the effect of SPSS course on student attitudes and achievement in statistics. The results of the study showed that SPSS course did not improve student attitudes toward statistics, but it increased knowledge and skills in the use of statistical sciences. Gillian (2012) indicated Critics of using technology in teaching statistics argue that students spend time learning technology, not statistics. In the same context, Mathews and Musonda (2018) conducted a study to explore the effect of instruction with SPSS on students' achievement and attitude towards hypothesis testing at Zambia University. The study found that students' attitudes towards learning statistics through technology improved, and SPSS may be an effective tool for teaching hypothesis testing to students at universities.

ChatGPT in Context of Statistics Learning

ChatGPT is a chatbot that mimics human language, and its working principle is based on big data, so it is able to learn and create a consistent dialogue within the required context (Omer & Enis, 2023). Because of this feature, research has shown that ChatGPT is considered supportive of the learning process and increases motivation toward learning by increasing the ability to work as an efficient assistant for teachers or as a virtual teacher for students by answering their frequently asked questions, supporting self-directed learners, and developing self-study skills in these students (Biswas, 2023; Lo, 2023). In addition to emphasizing that ChatGPT is capable of transforming the education process and supporting counseling and mental health education (Ajlouni et al., 2023). According to Supriyadi and Kuncoro (2023), AI is expected to revolutionize mathematics education. This field will witness the merging of technology and AI in one crucible in order to enrich the learning experience for students and develop computational thinking and statistics. In order to identify attitudes towards AI, various studies have been conducted, the most noteworthy of which is ChatGPT technology and its impact on mathematics education. Yilmaz et al. (2023) revealed a positive perception of ChatGPT among "science and mathematics education" students. Also, Lee and Yeo's (2022) state that AI-based chatbots promote students' mathematical reasoning and positive attitudes toward mathematics. Wardat et al. (2023) employed a qualitative methodology consisting of two stages to investigate the perspectives of students and educators on the utilization of ChatGPT in the field of mathematics. During the initial stage, ChatGPT's

application to teaching mathematics received a widespread and favorable response on social media. ChatGPT enhanced mathematical skills and elevated academic performance. However, the second phase revealed numerous limitations in its use, including a lack of understanding of the material and an inability to effectively correct errors. Dao and Le (2023) emphasize the significant potential of ChatGPT as a tool in information and communication technology for teaching how to solve basic issues, providing solutions, and explaining mathematical concepts. Conversely, Frieder et al. (2023) discovered that GPT-4 is only employed as a mathematical search engine. Sengur (2023) confirmed that ChatGPT is effective and productive when applied within the MATLAB statistical toolbox for social science research, Albeit in a distinct setting. The primary advantage of its functionality is its ability to effectively analyze large amounts of unstructured textual material. Although there are varying opinions regarding its integration into the educational process, certain studies have demonstrated favorable attitudes toward its utilization in learning. For instance, Ajlouni et al.'s (2023) study revealed that undergraduates at the University of Jordan exhibited a favorable attitude toward employing ChatGPT as a learning tool. As well, the literature in instructional technology evident the effectiveness of integrating technology with education on skills, knowledge and psychological constructs such as motivation and attitudes across several discipline and academic level (Ajlouni, 2023; Ajlouni & Jaradat, 2020, 2021; Ajlouni et al., 2018, 2023). Therefore, the study emphasized the significance of integrating ChatGPT into educational curricula and practices while also considering the potential hazards associated with its inappropriate utilization.

PURPOSE & STUDY HYPOTHESES

This study discusses the influences of utilizing ChatGPT in learning statistics on statistical reasoning and attitudes towards statistics among undergraduates. This study attempts to test the following hypotheses:

Hypotheses 1. There are no statistically significant differences at the significance level of $\alpha \leq 0.05$ between the means of the two groups' in statistical reasoning among undergraduates, attributable to the instructional method.

Hypotheses 2. There are no statistically significant differences at the significance level of $\alpha \leq 0.05$ between the means of the two groups' in attitudes towards statistics among undergraduates, attributable to utilizing the instructional method.

METHOD

Researchers used a quasi-experimental design with pre- and post-tests was used for two groups (control and experimental). Approval to conduct this study was

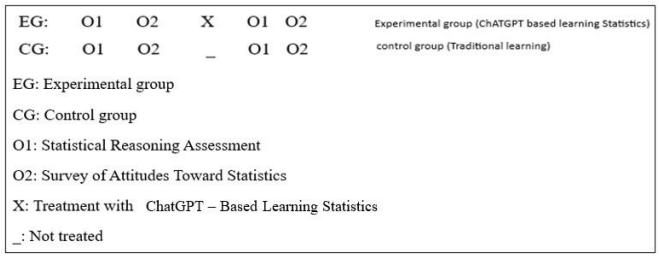

Figure 1. Study design (Source: Authors' own elaboration)

obtained from the Arab Open University administration. To collect data for the study, a reliable and valid assessment of statistical reasoning and attitudes towards statistics was administered. The university was selected purposefully, considering the criteria of offering multiple sections of mathematics courses, including statistics subjects. During the 2023-2024 academic year's first semester, we taught using blended learning strategies to facilitate self-learning skills. Two sections of mathematics for elementary school teachers were randomly assigned into two groups: the experimental group and the control group. The undergraduates in the control group were taught topics of statistics and probability using traditional teaching, where students rely on both physical course materials (such as textbooks or handouts) and online resources (such as websites or databases) to gather information and complete their educational activities, while the experimental group taught the same topic using ChatGPT. The attitudes towards statistics and statistical reasoning were assessed for study groups before and after they were taught the statistics and probability topics. In this study, the instructional approach was the independent variable (traditional, ChatGPT-based learning statistics), while the dependent variables were statistical reasoning and attitudes towards statistics. Data from pretest-posttest assessments for each group were analyzed descriptively and inferentially. The gathered data were analyzed using the Statistical Package for the Social Sciences (SPSS) software to illustrate the impact of ChatGPT-based learning statistics on statistical reasoning and students' attitudes. The study design is shown in **Figure 1**.

Samples & Procedures

A total of 56 undergraduate' students who enrolled in a mathematics for elementary school teachers' course at Arab Open University in Jordan during the first semester of the academic year 2023-2024 participated in the study. All students' academic specialization is Bachelor of Science in elementary school teachers. The pilot sample consisted of 45 (undergraduate) students who'd registered in the elementary school teachers' program at Arab Open University during the first semester of 2023-2024 and were outside the study sample. Informed consent was obtained from each participant. The study purpose was explained

Table 1. Demographic attributes of study participants

No	Attributes		Frequency	Percentage
1	Gender	Male	1	1.8
		Female	55	98.2
2	GPA	Excellent	1	1.8
		Very good	7	12.5
		Good	37	66.1
		Poor	11	19.6
3	School year	First	0	0.0
		Second	23	41.1
		Third	20	35.7
		Fourth	13	23.2

extensively to the participants. **Table 1** shows the demographic characteristics of the participants.

The subjects of statistics and probability were instructed in both groups by the same instructor through blended learning methods. The subject matter was covered over a duration of three weeks, with a total of nine hours using a blended learning strategy. Furthermore, the experimental group received a two-hour introductory session on the utilization of "ChatGPT" applications before the study started. In the classroom setting, the instructor applied the same learning content and guided learning activities for both groups. The same learning materials and activities for both groups were uploaded onto the Moodle learning content management system. The instructor's role primarily incorporated facilitating the learning process by engaging in daily queries and discussions and helping. For both groups, students were required to fulfill a set of learning tasks, comprising four individual homework assignments to be completed at home as well as four collaborative classroom activities carried out during class time in groups of four students, as shown in **Figure 2**.

In the experimental group, students use ChatGPT as a tool for learning and completing learning activities. Students incorporate ChatGPT, an AI-based tool, as part of their learning process and tasks related to statistical analysis and probability. This suggests that ChatGPT may assist students in tasks such as data analysis, hypothesis testing, generating probability distributions, or solving statistical problems. In contrast, the control group adheres to conventional instructional methods, utilizing course materials and the internet to search for data and complete their learning activities and individual homework assignments. Students in the experimental group had access to ChatGPT during and outside of class, just as the control group could access the internet for searching for information and learning at any time.

In a traditional statistics course, students test hypotheses following a set of steps. In this process, the hypothesis is defined, data is collected, descriptive statistics (mean and standard deviation) are calculated, significance level is determined, test statistic is calculated, critical value is found, comparisons are made, and finally a decision is made. The student interprets the results based on their understanding and knowledge. However, when employing ChatGPT in statistics, it performs these calculations while providing justifications for their use and offers step-by-step guidance. It can provide multiple examples, detailed steps, logical explanations, and reasons for choosing the appropriate test. For each task given to students, ChatGPT can explain how the solution was reached and how the results were interpreted in a detailed and comprehensive manner.

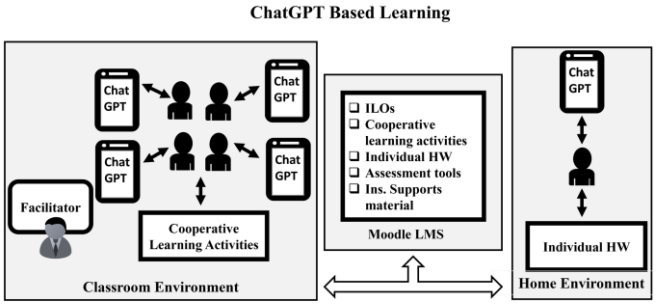

Figure 2. Experiment implementation procedures (Source: Authors' own elaboration)

Instruments

Two instruments were utilized for data collection in this study. Initially, the instruments were translated from English to Arabic, recognizing Arabic as the official language of Jordan. Subsequently, the translated instruments were assessed by a panel of eight specialists proficient in Arabic and English languages, psychology, measurement and assessment, and mathematics teaching. Following this review, the instruments were administered to a pilot sample comprising 45 students to confirm their validity and reliability.

Statistical Reasoning Assessment

The assessment of statistical reasoning (SRA), developed by Garfield (2003), was employed to gather information about students' ability to comprehend statistical concepts and apply logical statistical reasoning. SRA was designed to evaluate students' correct reasoning abilities as well as misconceptions across eight different areas. It is comprised of two subscales, namely, correct reasoning skills and misconceptions. It contains 20 multiple-choice questions. Each question may have a single correct response or multiple correct responses (Liu & Garfield, 2002).

Previous studies have approved the reliability and validity of SRA (Estrada, 2002; Garfield, 2003). The instrument has been administered to prospective primary education teachers, high school students, and college students in various statistics courses. It has also been utilized in research projects across multiple countries, such as Australia and the United Kingdom

(Garfield, 2003; Gaviria-Bedoya et al., 2022). Additionally, SRA has been translated and adapted into other languages, such as Spanish and French (Liu & Garfield, 2002). In addition, to ensure the psychometric properties of SRA, the researchers obtained Cronbach's alpha values of 82.0%, which affirm that SAR is a suitable measurement tool for this investigation.

Survey of Attitudes Toward Statistics

Survey of attitudes toward statistics (SATS), developed by Schau et al. (1995), was utilized to assess students' attitudes towards statistics. There are two copyrighted versions of SATS available: SATS-28 and SATS-36. SATS-28 was used in this study and employed to collect data regarding attitudes toward statistics.

SATS-28 comprises 28 items distributed over four subscales, which are: the affect subscale (six items), the cognitive competence subscale (six items), the value subscale (nine items), and the difficulty subscale (seven items). Each subscale's potential score ranges between one and seven, with higher scores indicating more positive attitudes. This instrument has been translated into several languages and employed in multiple countries (Sin & Rosli 2020). Within this scale, researchers evaluated participants' levels of attitudes toward statistics. Previous studies have confirmed the reliability and validity of the SATS-28 among undergraduate students (Ayebo et al., 2019; Schau et al., 1995; Sin & Rosli 2020).

Additionally, the validity and reliability of SATS were ensured by researchers through conducting a pilot study among 45 undergraduates' students. The person correlation coefficient (PCC) between each item of SATS and the overall SATA score ranged between (0.620-0.534), and PCC between each item of SATS in their belonging scale was above (0.534). Additionally, researchers extracted the subscale correlations of SATS; they were significantly correlated for all pairs of SATS's subscales, and all the subscales' correlations were in an acceptable range. Also, researchers confirmed the reliability of the scale by utilizing internal consistency. Cronbach's alpha coefficients were computed for each subscale and total scale, as shown in **Table 2**. These values indicate that SATS is a valid and reliable measure that can be used to collect data for this investigation.

Analysis of Data

In order to describe the study variables, descriptive statistics were computed, including the mean and standard deviation. Additionally, a one-way analysis of covariance (ANCOVA) was performed to assess whether the post-test means of the study groups differed statistically significantly. To ensure normal distribution and homogeneity of the data, Kolmogorov-Smirnov and Levene tests were conducted. Further, the eta square value was calculated to determine how the instructional method affected the dependent variables (attitudes toward statistics and statistical reasoning). The statistical computations were performed using SPSS software.

Table 2. Cronbach's alphas for SATS scale

Subscale	Cronbach's alphas
Affect	0.80
Cognitive competence	0.85
Value	0.77
Difficulty	0.76
Total scale	0.79

Table 3. Means & standard deviations of undergraduate pre- & post-test SRA scores

Group	n	Pre-test		Post-test	
		SD	M	SD	M
Experimental	28	1.32	3.54	2.05	11.07
Control	28	1.34	3.61	1.78	9.28
Total	56	1.32	3.57	2.11	10.18

Note. n: Number of participants; M: Mean; & SD: Standard deviation

FINDINGS & DISCUSSION

Impact of ChatGPT based Learning Statistics on Undergraduates' Statistical Reasoning

Hypotheses 1. There are no statistically significant differences at the significance level of $\alpha \leq 0.05$ between the means of the two groups' in statistical reasoning among undergraduates, attributable to utilizing the instructional method.

In addressing this study hypotheses, the researchers extracted descriptive statistics in terms of mean and standard deviation for the participants' pre- and post-test scores on the SRA, as presented in **Table 3**. The results indicated that the mean scores for both groups on the SRA pre-test were similar (3.54, 3.61). In addition, it demonstrated an apparent difference in the statistical reasoning post-test mean scores between study groups. The experimental group exhibited a greater mean. Specifically, the post-test mean score for the experimental group reached (11.07), whereas the control group's mean score was (9.28), indicating an apparent difference in students' statistical reasoning in favor of the experimental group's instructional method.

Normality and homogeneity tests were used to make sure the conditions for ANCOVA were met. Then, a one-way ANCOVA analysis was done to see if these differences were statistically significant. It was confirmed that the statistical resonating data met the criteria of normal distribution and homogeneity. Furthermore, the partial eta squared was calculated to determine the proportion of variance attributable to the instructional method. The outcomes of these investigations are presented in **Table 4**.

Table 4. ANCOVA results for undergraduates' post-test SRA scores

Source of variation	Sum square	df	Mean square	F	Sig.	η^2
SRA pre-test	5.334E-5	1	5.334E-5	.000	.997	.000
Instructional method	44.612207	1	44.612	11.848	.001	.183
Error	199.571375	53	3.765			
Adjusted total	244.214	55				

Note. Sig.: Significant; df: Degrees of freedom; F: F-test; & η^2: Partial eta squared

Table 4 demonstrated significant differences (α≤0.05) in SRA post-test scores among the study groups, as evidenced by the extracted F-value (11.848). Furthermore, the achieved partial eta squared (0.183) indicates that 18.3% of the explained variance in the total score of the post-test of SRA scores between the experimental and control groups is due to the use of instructional method.

To determine which group benefited from the differences, the adjusted mean of the posttest scores was calculated. The adjusted mean for the experimental group reached 11.24, while for the control group it reached 9.25. This indicates that ChatGPT-based learning significantly enhanced Statistical reasoning.. Specifically, students who engaged in ChatGPT-based learning exhibited a higher level of statistical reasoning in comparison to their colleagues who were taught using traditional learning method. The implementation of statistical tasks using ChatGPT placed students in the experimental group in a learning environment of modernity and interaction. It provided students with a customized educational experience that helped them understand statistical symbols and use them in accordance with their abilities, capabilities, and self-speed. And therefore, considering individual differences among students and individualizing their learning process, this enabled them to think and understand correctly these symbols and increase their mastery of statistical concepts, thus improving the level of statistical resonance in the first level (Supriyadi & Kuncoro, 2023).

Employing ChatGPT contributed to the introduction of the statistical material in a manner based on dialogue and discussion that simulates the human method, as it provided them with basic statistical knowledge. By providing them with a huge number of examples and answering questions without getting bored, as if he were a tutor for the student at any time, he also encouraged them to follow through on completing the tasks assigned to them, in addition to providing them with information in various forms that helped them test their knowledge. Which led to improved knowledge of different statistical ideas (level two in statistical resonating) (Wardat et al., 2023).

This result can be attributed to the nature of ChatGPT as a statistical assistant, where students can search, read, ask questions, find information and answers, and provide the mathematical assistance needed to perform the statistical task correctly. In addition to providing learners with immediate feedback to explain mathematical concepts, solve basic problems, and thus fully understand statistical tasks and operations, this helps to develop statistical reasoning at the third and fourth levels (Dao& Le, 2023; Petersen & Berner, 2023).

ChatGPT has the ability to process large amounts of unstructured or incomplete text data. It can also create different types of visual data, such as graphs. Thus, it is easier for students to explore and understand statistical results and to perform complex statistical analyses easily and quickly, in addition to being able to create reports that summarize and analyze these results, which gives students comprehensive and integrated knowledge of statistical tasks and employs them in solving various problems, thus improving statistical reasoning in the fifth level and in general (Sengur, 2023).

The results of this study are consistent with the findings of the Ramadhani and Evans (2022) study, whose results showed the effectiveness of using statistical applications in developing and enhancing students' statistical thinking abilities as a result of the possibility of displaying statistical information visually and thus facilitating the organization and analysis of data. It also agrees with the results of the study by Lee and Yeo (2022), which showed the ability of AI-based chatbots to develop students' mathematical reasoning skills. While the results of this study differed from the results of the study by Wardat et al. (2023), which showed the inability of ChatGPT to correct mathematical misconceptions appropriately.

In light of the ABC model of attitude, this result could be explained by the fact that ChatGPT could foster the components of attitude (affective, behavioral, and cognitive) (Khalil et al., 2020) by making the learning process more engaging, enjoyable, and less intimidating. After using ChatGPT to learn statistics, students may exhibit positive behavioral changes, such as increased participation, effort, and persistence in completing statistics-related tasks. They may also demonstrate a willingness to explore statistical concepts further and engage in problem-solving activities with greater enthusiasm. Additionally, ChatGPT may enhance students' cognitive understanding of statistics by providing clear explanations, answering questions, and offering additional practice opportunities. As a result, students may develop more positive beliefs about their abilities to understand and succeed in statistics, leading to an overall improvement in statistical reasoning.

Impact of Using ChatGPT in Learning Statistics on Undergraduates' Attitudes Towards Statistics

Hypotheses 2. There are no statistically significant differences at the significance level of α≤0.05 between the

Table 5. Means & standard deviations of undergraduate pre- & post-test SATS scores

Group	n	Pre-test		Post-test	
		SD	M	SD	M
Experimental	28	0.55	2.9	0.22	4.55
Control	28	0.65	1.87	0.46	2.06
Total	56	0.8	2.40	1.30	3.30

Note. n: Number of participants; M: Mean; & SD: Standard deviation

means of the two groups' attitudes towards statistics among undergraduates, attributable to utilizing the instructional method.

In addressing this study Hypotheses, the researchers extracted descriptive statistics in terms of mean and standard deviation for the participants' pre- and post-test scores on the SATS, as presented in **Table 5**. The results indicated that the mean scores for both groups on SATS pre-test were almost similar (2.90, 1.87). In addition, it demonstrated an apparent difference in attitudes towards statistics post-test mean scores between study groups. The extremital group exhibited a greater mean. Specifically, the post-test mean score for the experimental group reached (4.55), whereas the control group's mean score was (2.06), indicating an apparent difference in students' attitudes towards statistics in favor of the experimental group's instructional approach or learning method.

Normality and homogeneity tests were used to make sure the conditions for ANCOVA were met. Then, a one-way ANCOVA analysis was done to see if these differences were statistically significant. It was confirmed that attitudes towards statistical data met the criteria of normal distribution and homogeneity. Furthermore, the partial eta squared was calculated to determine the proportion of variance attributable to the instructional approaches. The outcomes of these investigations are presented in **Table 6**.

Table 6 demonstrated significant differences ($\alpha \leq 0.05$) in SATS post-test scores among the study groups, as evident from the extracted F-value (372.777). Furthermore, the partial eta squared was achieved (0.876), indicating a medium impact of the instructional methods on enhancing attitudes towards statistics.

To determine which group benefited from the differences, the adjusted mean of the posttest scores was calculated. The adjusted mean for the experimental group reached 2.6, while for the control group it reached 1.75. This indicates that ChatGPT-based learning significantly enhanced attitudes towards statistics. These findings indicate that students who utilized ChatGPT-based learning for statistics exhibited a more significant enhancement in their attitudes towards statistics in comparison to their classmates who employed learning techniques.

Table 6. ANCOVA results for undergraduates' post-test SATS scores

Source of variation	Sum square	df	Mean square	F	Sig.	η^2
SRA pre-test	1.777	1	1.777	18.133	.000	0.255
Instructional method	36.537	1	36.537	372.777	.000	0.876
Error	5.195	53	.098			
Adjusted total	93.549	55				

Note. Sig.: Significant; df: Degrees of freedom; F: F-test; & η^2: Partial eta squared

This result could be explained, as follows: ChatGPT could provide immediate and private communication tailored to individual needs. Consequently, they can tackle statistical problems and respond to any inquiries without any reluctance or worry about repeating themselves. As a result, students feel comfortable and confident, which helps them learn statistics without feeling excessive stress. As a result, students have an increased level of fun when learning statistics and a boosted level of confidence. Consequently, this has a beneficial effect on pupils' attitudes towards learning statistics (Yalms, 2023).

In addition to the above, the ability of ChatGPT to customize the learning experience to individual needs and train students to solve statistical problems by providing a huge number of different statistical examples in different ways and allowing statistical errors to be made while providing immediate feedback so that it helps students understand statistical structures and concepts, which improves their thinking skills and thus improves the cognitive competence needed to learn statistics, as the Ghulami et al. (2015) study indicated that the formation of positive trends takes place during the transfer of knowledge. Also, ChatGPT offers a new personal learning experience as a result of the change in students' needs, as Farooq and Shah's (2008) study emphasizes that attitudes change with changing needs and the role in the individual's environment and allows for enhancing creativity, in addition to introducing a new way of thinking and allowing the use of statistical knowledge in solving daily life problems by enhancing the opportunity to employ statistical skills in solving life problems, which enhances the value of students learning statistics.

Allowing students to access a huge database, solving complex statistical issues with ease, allowing self-study, increasing student participation and communication between them, allowing the student to be an active learner (Judi et al., 2011), and thus raising students' learning efficiency for statistics and improving their level of understanding of statistical topics And increasing their statistical knowledge, which leads to an easier understanding of statistics and changing beliefs about the difficulty of this subject, thus improving

attitudes towards learning it, as indicated by a study by Jatnika (2015).

In summary, the positive attitude towards statistics after using ChatGPT in learning can be explained by the affective, behavioral, and cognitive components of ABC model (Mazana et al., 2019). By fostering positive emotions, encouraging favorable behaviors, and enhancing cognitive understanding, ChatGPT contributes to a more positive overall attitude towards statistics among students.

The result of this study is consistent with Lee and Yeo's (2022) study, which showed the ability of AI-based chatbots to develop positive attitudes toward mathematics in general because of their multiple advantages in answering students' frequently asked questions. It is also consistent with the results of the Mathews and Musonda (2018) study. Which showed a significant improvement in students' attitudes toward learning statistics through technology, while the results of the current study differed from the results of the Jatnika's (2015) study, which confirmed the inability of statistical applications to improve students' attitudes toward statistics, and this can be attributed to the inability of these packages to give many examples and answers to students' questions, as they display the data entered by students only and in the form of tables.

CONCLUSIONS & RECOMMENDATIONS

In recent years, the world has witnessed an unprecedented information and technology revolution, which has led to the emergence of technological tools and applications supported by AI. This technological development has been reflected in the education system in particular, and the use of these tools and applications has become important and decisive in achieving the goals of sustainable development by reaching high-quality education. In light of the desire to benefit from the advantages of AI applications that are capable of drawing conclusions and dealing with incomplete data, many studies have been conducted in this field. It is noteworthy that the current study, which stands out for its modernity, is the first study to examine and combine one of the most well-known applications of AI, ChatGPT, and its impact on developing the cognitive aspects represented by statistical reasoning and the non-cognitive aspects represented by attitudes toward statistics among the group of university students. This study was applied in one of the private universities in Jordan during the first semester of 2023–2024 on a sample of 56 male and female students, distributing them equally into two control and experimental groups. The study followed a quasi-experimental approach, and two valid and reliable assessments were used: measures of statistical reasoning (SRA) and attitude toward statistics (SATS). The results indicated the efficiency of using ChatGPT as an educational tool for developing statistical reasoning skills and promoting positive attitudes toward learning statistics.

Limitations & Future Research

Despite the importance Results of this study, there are several limitations due to the small sample size, a larger sample size may lead to obtaining more valuable information in this field. The application was limited to a sample of students from one university, namely the Arab Open University in Jordan, for a relatively short time. However, the researchers recommend expanding the use of Chat GBT in statistics lessons and encouraging teachers and students to use it in their learning of statistics, in addition to conducting more experimental and qualitative studies in this context due to the lack of studies that have addressed this extremely important topic.

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Data sharing statement: Data supporting the findings and conclusions are available upon request from the corresponding author.

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