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PAPER

The Impact of Artificial Intelligence on Computational Thinking in Education at University

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ABSTRACT

This study aims to reveal the role of one of the artificial intelligence (AI) techniques, "ChatGPT," in improving the educational process by following it as a teaching method for the subject of automatic analysis for students of the Chemistry Department and the subject of computer security for students of the Computer Science Department, from the fourth stage at the College of Education for Pure Science (Ibn Al-Haitham), and its impact on their computational thinking to have a good educational environment. The experimental approach was used, and the research samples were chosen intentionally by the research community. Research tools were prepared, which included a scale for CT that included 12 items and the achievement test in both scientific subjects for departments as the second tool. They reached a lot of conclusions. Accordingly, a set of recommendations were proposed.

KEYWORDS

effect, artificial intelligence (AI), ChatGPT, computational thinking, education, university, achievement, chemistry, computer science, students

1 INTRODUCTION

In Iraq, higher education institutions in general and the University of Baghdad in particular seek to change and develop their programs and strategies to keep pace with the accelerating global changes in all fields, including the digital and technological revolution, so they decided to invest in artificial intelligence (AI) techniques in their activities to achieve the functions assigned to them, whether the function of teaching, scientific research, or community service. Educational institutions work to provide high-quality and attractive educational services and to develop various activities aimed at developing the student's personality [1]. Education is pivotal for the country's development, and the university has a fundamental role in it. Improving the quality of its educational services to achieve student satisfaction raises its aspects of excellence and competitiveness in the future in the era of digital technology and AI, and it has great potential for implementation in education [2–4].

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One of the recent developments in this area is the emergence of ChatGPT, an AI model that interacts with humans by understanding and generating natural language text. Today, the world is moving towards adapting to the trend of digital technology and harnessing the potential of AI while exploring the potential and challenges that this technology brings. ChatGPT will soon have many important roles in education and is receiving increasing attention from researchers around the world [5]. We live in a world built on data and content. With the availability of chatbots supported by AI. It is undeniable that ChatGPT is a powerful and versatile linguistic model. Researchers are examining the role of ChatGPT, specifically whether or not it can be used as an effective assessment tool and replace traditional assessment methods in higher education [6, 7]. Specifically, the College of Education for Pure Science (Ibn Al-Haitham) and the departments of computer science and chemistry because of their interrelationship in the use of arithmetic and algebraic skills.

In the first semester of the academic year 2023–2024, researchers from the College of Education for Pure Science (Ibn Al-Haitham) at the University of Baghdad conducted a study involving students in the fourth stage of both the chemistry and computer science departments. The study aims to answer:

Q1. What's the impact of ChatGPT on the computational thinking and academic achievement of students in the departments of chemistry and computer science?
Q2. Is there a difference in the level of academic achievement between students in the chemistry and computer science departments?
Q3. Is there a difference in the level of computational thinking among students in both departments?

The importance of the study stems from a few points, such as the importance of AI technologies, including ChatGPT, and the importance of using them in the educational process, especially university education [8, 9]. Investing in the use of this ChatGPT technology in the educational process and its impact on developing students' computational thinking. Exploding the creative energies of students by developing and expanding students' knowledge in the field of using this technology and its continuous development to support the educational process [10, 11]. Developing computational thinking is a key skill that all students must master to be able to coexist in contemporary society and be able to solve problems. Enriching modern teaching methods in teaching chemistry or mathematics keeps pace with students' interest in educational technology and is not limited to traditional methods of education [12, 13].

This helps teachers provide targeted support and resources to help students improve in areas that they desperately need. ChatGPT's AI chatbots are virtual teachers who can help students with inquiries and research, especially those who face learning difficulties or are smart people who are often shy and hesitate to ask a single question.

2 THEORETICAL BACKGROUND

2.1 Artificial intelligence

Artificial intelligence is one of the modern sciences related to computers that search for advanced and innovative methods to carry out actions and conclusions that are similar—albeit within narrow limits—to those reasons attributed to human intelligence, and its purpose is reconstruction using artificial means [14, 15]. Scientists have so far succeeded in developing AI models, including robots and

personal computers, that can conduct dialogue with humans and implement their voice commands. These models are still under development and experimentation and are being updated day after day [16].

ChatGPT origin. It is the latest chatbot developed by OpenAI. It is one of the largest language models ever created, with 175 billion standards. It gained wide public interest and was launched in early 2022. It is trained on a huge amount of text data, allowing it to produce human-like text in a wide range of fields. It is used in a variety of applications, including education, summarization, question-answering, and translation. It uses a range of machine learning (ML) techniques to create new images based on user input [17]. It is an AI technology and a modern strategic technology that works to produce knowledge by obtaining it and storing, processing, interpreting, and investing in solving problems and providing new services, including developing computer thinking, adopting problem-solving methods, designing systems, and understanding student behavior that depends on basic computer concepts [18]. Issues related to curricula and teaching methods are important challenges that are concerned with comparative educational institutions, especially in the wake of the creation of a set of methodological tools at the beginning of the 21st century that may benefit researchers in the field of curricula and teaching methods. This contributes to strengthening the link between science and mathematics, and this is confirmed by the discussions presented by solid scientific studies; among them arise the inventions and technological innovations that society needs, as stated [19, 20]. The ultimate goal should not be to teach everyone to think like computer scientists but rather to teach them how to apply these common elements to solve problems and discover new questions that can be explored within all disciplines and others.

It is a large language model created by OpenAI that uses ML methods to understand and produce human-like language. It is a laboratory that studies AI to come up with an idea. It reacts realistically, even answers subsequent questions, and admits his mistakes [21]. Its an AI-powered chatbot to talk to users about a variety of topics, from simple small talk to complex technical conversations. It can produce consistent, context-appropriate responses to user input because it has been pre-trained to handle huge amounts of data.

The GPT-3.5 version was used; it's free and available to students in teaching chemistry and automated analysis; and in computer security. By using equations and mathematics, students can pose problems using ChatGPT and get immediate feedback. It helps students understand mathematical problems and solutions by providing suggestions, discovering errors, automatic code, mathematical and chemical equations, and even any problem facing students. The students can get personalized education tailored to their learning pace [22].

Advantages of ChatGPT in university education.

1. Support teaching and automated answers using ChatGPT to create automated systems to answer questions and provide solutions to learning problems. It helps improve the effectiveness of teaching and learning [23, 24].
2. ChatGPT can act as a virtual tutor, providing guidance and training to students in many areas [25].
3. Provides personalized educational support by interacting with students to understand their individual needs and abilities. Creating personalized educational content and recommending appropriate materials and exercises for each student helps improve learning efficiency and discover the potential of each individual [26].
4. It helps us understand the student's mood during lectures using gesture recognition technology [25].

5. Process improvement works as a standalone tool that can be integrated into other systems and platforms used by higher education institutions [27].
6. Its strong ability to organize knowledge, improve learning and research efficiency, improve the quality of higher education, and comprehensively transfer knowledge to cultivate students' creative and computational thinking.

2.2 Computational thinking

The 21st-century learner must be equipped with many of these specific capabilities to meet the growing need to meet the increasingly complex challenges posed by rapid and escalating change and to meet complex challenges as part of the fourth revolution, AI [28]. Since computational thinking (CT) is a way in which humans solve problems using computers, education is the extent to which computers and technology are used and thus facilitates the pedagogical relationship between them. This, in many respects, is about helping teachers in the classroom learn economics, labor, and environmental technology [26, 29, 30].

It consists of mental skills, practices, and basic methods for solving complex problems [31].

One of its most prominent definitions is the procedural definition provided by the American Computer Science Educators Association (CSTA) in cooperation with the International Society for Technology in Education (ISTE) as a problem-solving process that includes: formulating problems in a way that enables the use of computers and other tools to help solve them; identifying, analyzing, and implementing them. Possible solutions to reach the most efficient and effective combination of steps and sources include logical organization of data and analysis, representation of data through abstractions such as models and simulations, automation of solutions through algorithmic thinking, generalization, and benefiting from the process of solving the problem that the individual is dealing with and applying it to a wide range of problems [35].

It is defined as how computer scientists think, and infer reason. Informally, it describes mental activity in formulating a problem to solve it. Recognized as a computational solution, the solution can be implemented by a human, a machine, or, more generally, by combinations of humans and machines [32].

It is necessary to teach students CT to develop opportunities for creativity in solving problems, as well as to move learners from consumers of technology to producers [32]. Patterns of thinking involved in CT are critical, logical, abstract, proactive, and procedural thinking [33].

Characteristics of computational thinking. According to [34], CT:

1. is a key skill, not a routine one
2. includes mathematical and geometric thinking
3. focuses on concepts, not programming
4. is the way humans think, not the way computers think
5. focuses on ideas, not just tools
6. can be used anywhere and anytime

Computational thinking skills.

1. Abstraction aims at simplification and requires specifying the dimensions of the problem and hiding the rest of the details by isolating or excluding irrelevant details. It is considered the most important and highest-level thinking process in CT [35].

2. Analysis is a way of thinking about the parts of a problem. It helps the individual understand the parts and components they contain, solve, develop, and evaluate them individually, and it also makes complex problems easier to solve [36, 37].
3. Algorithmic design: It's a way to solve a problem by clearly defining the necessary steps and specifying inputs, processes, and outputs [38, 39].
4. Evaluation: This means identifying possible solutions to a problem and deciding which is the best, which of them can be useful in some cases but not all of them, and how they can be improved. We can test whether the solutions are working correctly by giving them a lot of different inputs to see if they are working as they should [40].
5. Generalization: It's taking advantage of the processes used to solve a specific computer problem and applying them to a variety of problems. It's solving new problems quickly based on previous problems that the individual has solved.
6. Logical thinking means trying to understand things logically through observation, collecting data, thinking about the facts we know, and then deducing things based on what we already know to set rules and test the facts on a deeper level [41, 42].

2.3 Academic achievement

It is everything that a student obtains and achieves in terms of achievements and desired changes in his knowledge, skills, and attitudes as a result of the activities and scientific experiences that he has undergone, or the sum of what the student is expected to obtain and master as a result of studying for a year of study, or a specific academic stage [36].

2.4 Related work

Table 1 presents the details of previous work done in this field.

Table 1. Previous studies

Name; Year; Country	Class	Sample	Curriculum	Tools	Results
[43]	3rd stage College	100 male and female	Descriptive	CT test	They have Computational Thinking.
[44]	7th grade in middle school	48 male and female	Experimental	The unplugged CS activity	Pre-service teachers stated that they had challenges in classroom management during the activity. Classroom management should be a part of teacher education in designing and implementing CT-integrated lessons.
[45]	university students	100 male and female	Analytical	A comprehensive analysis of the origin and working mechanism of ChatGPT in various fields such as mathematics, science, history, and geography	The study provided an evaluation of the impact of ChatGPT on different fields of study, such as languages, mathematics, science, arts, history, and geography1. The study reviewed the advantages, disadvantages, and risks associated with using ChatGPT in these fields, and how researchers and scientists can benefit from its potential in creating innovative content.

3 METHODOLOGY

The researchers relied on the experimental research approach including an experimental design for two ('experimental' and 'control') groups with a post-test (real designs) to obtain results to prove the research hypotheses. The influencing factors were controlled, and the procedures were adjusted [46].

The research population comprised of students from the College of Education for Pure Science (Ibn Al-Haitham) and the sample was intentionally selected from students of the chemistry department and the computer science department for the academic year 2023–2024. Researchers chose 146 male and female students who were chosen intentionally, including 94 male and female students 33% from the chemistry department and 52 male and female students 47% from the computer department, as shown in Table 2.

Table 2. The research community and sample

Research Community	Groups Percentage	No. of Std.	Research Sample	Groups Percentage	No. of Std.
Chem.	72%	285	Chem.	33%	94
Comp.	28%	110	Comp.	47%	52
Total Community	100%	395	Final Sample	37%	146

Researchers prepared two research tools, which were: a 5-point Likart scale questionnaire for CT that included 12 items distributed so that the skills for CT were determined. The internal consistency and stability of the scale were confirmed; its value was 91% according to the Cronbach equation [47].

As for the second tool, it was represented by the achievement test in the scientific subject for both departments (lectures on instrumental analytical chemistry) and (lectures on computer security). It consisted of 15 multiple-choice items and five between solving mathematical problems and an essay answer. The initial image of the test was confirmed by presenting it to specialized arbitrators and expressing their opinions to ensure the validity of the test. The amendment was made according to their opinions by 82%, and based on the Cronbach's alpha equation, the reliability coefficient reached 88%.

4 RESULTS

The current study investigates the impact of ChatGPT on "Achiv." and "CT"; so the CT scale was distributed before starting to implement the GPT on "Experi." and "Cont." groups for the students of the Chemistry Department and also the "experimental and control" for the Computer Science Department students. Then the same procedures for "Achieve. Test" were done. After obtaining the results, a comparison is made between the results of the achievement test (AT) and computational thinking scale (CTS) for the experimental group among the students of the Chemistry and Computer Departments to find out which of the two sections ChatGPT had a greater impact. The data were processed using the statistical package for the social sciences (SPSS) and the Mann-Whitney test for heterogeneity in the distribution of data for research groups.

4.1 Chemistry Department

Table 3. The achievement scores of students in the Chemistry Department

Groups	No.	Median	Rank Sum	Mann-Whitney U Value		Z-Score		Statistical Significance
				Cal.	Tab.	Cal.	Sch.	
Exp.	48	48.36	255.5	149.5	182	4.19	1.96	statistically significant
Students	46	43.68	223.5					

From Table 3, the average rank for the experimental group was 48.36, greater than that of the control group which had 43.68, and the z-value was greater than the tabulated one. Thus, the null hypothesis is rejected in favor of the experimental group.

Table 4. The effect size of the ChatGPT on the achievement/Chem.

ChatGPT	Effect Size r	Criterion
Achievement	0.54	Large

It is clear from Table 4 that ESV = (0.54) is an appropriate value to interpret the effect size and is large according to the scale (0.3, 0.4, 0.5), (small, medium, large), respectively [48].

Table 5. The CT scores for students in the Chem. Dep.

Groups	No.	Median	Rank Sum	Mann-Whitney U Value		Z-Score		Statistical Significance
				Cal.	Tab.	Calculated	Sch.	
Exp.	48	59.71	286.6	158.48	182	4.48	1.96	statistically significant
Stu.	46	34.76	159.9					

From Table 5, it is clear that the experimental group of the Chemistry Department has the CT variable, and thus the null hypothesis is rejected.

Table 6. The effect size of "ChatGPT" on "CT" for students from Chemistry Dep.

ChatGPT	Effect Size r	Criterion
CT	3.93	Small

As in Table 6: The size of the effect was small because of ChatGPT on the CT of the Chemistry Department.

4.2 Computer Science Department

Table 7. The achievement scores of students from Computer Science Department

Group	No.	Median	Rank Sum	Mann-Whitney U Value		Z-Score		Statistical Sig.
				Cal.	Sch.	Cal.	Tab.	
Exp.	27	30.76	830.5	122.5	182	2.205	1.96	Statistically Sig.
Students	25	21.9	547.5					

From Table 7, it seems that the null hypothesis is rejected in favor of the experimental group.

Table 8. The effect size of ChatGPT on the achievement of computer science department

ChatGPT	Effect Size r	Criterion
Achievement	0.76	Large

It is very clear from Table 8 that the effect size value is large.

Table 9. The CT scores for students from Computer Science Department

Group	No.	Median	Rank Sum	Mann-Whitney U Value		Z-Score		Sta. Sig.
				Cal.	Sch.	Cal.	Tab.	
Exp.	27	39	1053	156	182	4.01	1.96	Sig.
Students	25	13	325					

From Table 9, the value of the average rank for the expert group is 39, which is greater than the control group, which is 13. This indicates that there is a statistically significant difference at the level of 0.05 between the two groups in favor of the experimental group in the CT variable.

Table 10. The effect size of ChatGPT on the CT/Com. Dep.

ChatGPT	Effect Size r	Criterion
CT	0.753	Large

From Table 10, it is clear that the effect size for the CT variable reached 0.753; that is, ChatGPT has a large effect.

4.3 Comparison between both departments

Table 11. Comparison of the achievement test between Chemistry and Computer Science Department

Exp.	No.	Mean	Rank Sum	Mann-Whitney U-Valued		Z-Score		Sta. Sig.
				Cal.	Sch.	Cal.	Tab.	
Com.	27	39.26	1060	146	182	2.03	1.96	statistically significant
Chem.	48	38.08	1866					

It is clear from Table 11 that the Computer Science Department excelled in the achievement variable.

Table 12. Comparison of the CT variable between the Chemistry and the Computer Science Department

Exp.	No.	Median	Rank Sum	Mann-Whitney U-Valued		Z-Score		Statistically Significance
				Cal.	Tab.	Cal.	Sch.	
Com.	27	58.72	1158.5	88.5	182	6.205	1.96	statistically significant
Chem.	48	26.34	1264.5					

From Table 12, it is clear that the Computer Science Department excelled over the Chemistry Department at computational thinking.

5 CONCLUSIONS

The study proved that ChatGPT has an impact on the superiority of "the experimental groups" compared to the "control" for both the Chemistry and Computer Departments. The computer department outperformed the chemistry department and increased students' motivation towards learning and developing their thinking skills.

6 RECOMMENDATIONS

The researchers recommend investing in ChatGPT technology to develop the educational process by preparing teachers well to be informed and using it in the lecture. Providing financial resources by the Ministry of Higher Education and Universities to the extent that allows the use of ChatGPT during lectures. Spreading awareness of this technology through educational courses and workshops on the benefits of employing this technology in the educational process. Creating programs for talented students in the field of robot programming and design to develop their capabilities and allocate prizes for them.

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