Assessing the Effectiveness of ChatGPT for Enhancing Programming Skills Among Second-Year Computer Science Students in Tunisia

Noureddine Aissa
Higher Institute Of Education And Continuing Training
University Of Tunisia
etudiant.aissa.noureddine@uvt.tn

Hédia Sellami Mhiri
Higher Institute Of Education And Continuing Training
University Of Tunisia
hedia.sellami@uvt.tn

***Abstract*—The integration of Artificial Intelligence (AI) into everyday life, including education, is rapidly expanding but faces challenges, particularly in aligning AI tools with educational theories and roles. This study investigates ChatGPT's use for learning programming in Tunisian secondary schools, using qualitative and quantitative methods. The research assessed AI's impact on students' coding and logical thinking. An experiment with three schools divided students into an AI-assisted group and a traditional instruction group, with pre-tests and post-tests measuring the impact. Results showed ChatGPT positively influences programming skills and logical reasoning. Despite limitations like small sample size and technical constraints, the study opens new research avenues. Future research should explore larger samples and various educational levels, examining long-term effects on problem-solving, emotional engagement, and readiness for complex challenges. Tailoring AI tools to specific contexts could enhance their effectiveness, marking a step toward integrating AI in education.**

Keywords*— Computer science education, Computational thinking, Generative artificial intelligence, Interactive learning environments.

I. Introduction

Advancements in technology have transformed computer science education, particularly in Tunisia, where the Ministry of Education introduced a new curriculum in September 2019 [1]. This curriculum emphasizes programming, computational thinking (CT), media literacy, and application development through innovative pedagogical techniques such as inquiry-based learning, project-based learning, and problem-solving [1].

Computational thinking skills, including programming, abstract thinking, problem-solving, pattern recognition, and logical reasoning, are crucial for both work and life [2]. However, pedagogical approaches to teach these skills have lagged behind subjects like mathematics and science [2], [3]. While students readily adopt technology and develop critical thinking, mastering basic programming concepts remains challenging [4].

Traditional search engines often provide irrelevant, disorganized results due to poor matching between query terms and web page keywords, leading to inconsistencies in information retrieval [5, 6, 7]. This emphasizes the need for students to express problems in natural language and highlights the importance of supervision, swift feedback, and clear explanations [8-10].

The use of AI-driven chatbots, particularly ChatGPT, has been proposed to revolutionize programming education. Studies show that chatbots improve memory retention, enhance learning, and increase participation [11-15]. AI tools also boost student engagement in computational problem-solving, enabling personalized instruction and objective assessment, while fostering critical thinking skills [16, 17].

This research explores the integration of ChatGPT in programming education for second-year Computer Science students in Tunisia. It examines the interactions between students and the AI-driven chatbot and assesses its impact on programming understanding, problem-solving, and academic performance. The study also investigates how ChatGPT affects students' development of computational thinking, problem-solving skills, and their ability to apply these skills in real programming scenarios. Additionally, it explores how ChatGPT may reduce difficulties with basic programming concepts.

The paper includes a literature review on AI in education, the challenges of teaching programming, theoretical foundations, and the study's structure. It also analyzes student-ChatGPT interactions, pedagogical strategies, and the impact on learning outcomes, concluding with implications for classroom practice, curriculum design, and educational policy.

II. Literature review

A. *Chatbot in education*

Recent studies highlight various uses of chatbots in education. Melián-González et al. [18] examined the shift from keyword-based systems to advanced Natural Language Processing (NLP), showcasing chatbots' evolving capabilities. Moriuchi et al. [19] discussed their roles in tasks like data collection and automation, such as booking and purchasing.

Shorey et al. [20] used chatbots in nursing education to teach communication skills, emphasizing immersive learning. Fryer et al. [9] compared student engagement with chatbots and peers in language courses, noting a decline in chatbot interest over time, revealing challenges in sustaining engagement.

Systematic reviews by Abd-alrazaq et al. [21] and Bendig et al. [22] explored chatbots' therapeutic uses in mental health and psychology. Winkler et al. [23] found that chatbot effectiveness depends on design, particularly meeting cognitive and emotional needs. Momonov et al. [24] likened chatbots to personalized learning tools. Colace et al. [25] confirmed chatbots' effectiveness in higher education, while Ayoub [26] developed a bot that autonomously manages course queries and content.

B. *ChatGPT in teaching/learning programming*

AI tools like ChatGPT are gaining significance in programming education. Yilmaz et al. [27] found that AI-based tools provide immediate feedback, improving coding efficiency and student engagement. However, ChatGPT's specific impact remains underexplored, as noted by Kasneci et al. [28], Lo [29], and Tlili et al. [30], who called for further investigation into its effectiveness.

Zhang et al. [31] reviewed AI in education, highlighting its potential to boost engagement and efficiency. Pedro et al. [32] examined AI's role in automating tasks and its implications for policy and ethics. Chen et al. [33] discussed AI's role in personalized learning and access, addressing ethical challenges.

Tlili et al. [30] and Kuhail et al. [34] emphasized how conversational agents like ChatGPT enhance learning experiences and foster motivation. Studies by Studente et al. [35] and Malinka et al. [36] showed that chatbots assist students, particularly freshmen, with content engagement and support. Kashefi et al. [37] found ChatGPT effective in solving complex programming problems.

Yilmaz et al. [27] and MacNeil et al. [38] highlighted ChatGPT's positive effects on students' computational thinking and understanding, with its ability to explain code examples facilitating learning in computer science.

C. *Theoretical Framing*

Constructivism, applied to learning Python with ChatGPT, promotes active knowledge building through interaction and personalized feedback [39]. Piaget's theory explains cognitive development through assimilation and accommodation of new knowledge [41, 42]. In education, it fosters active learning based on students' prior knowledge [43].

Personal Construct Theory (PCT), by George Kelly, focuses on how people predict and classify experiences using personal constructs. In education, PCT supports personalized learning, adapting teaching to each learner's unique understanding [44].

III. METHOD

A. *Tunisian Computer Science Section Curriculum*

Established in 2005 to meet market demands, this section provides in-depth programming training starting in the second year [45]. The 2022/2023 curriculum includes two modules: 'Computational Thinking and Programming' and 'Systems Technologies and the Internet.' The former uses Python and focuses on basic programming notions and data structures, while the latter covers web technologies and coding languages like HTML5 and CSS3.

B. *Research Design and Methodology*

This study, based on constructivist ontology, hypothesizes that ChatGPT enhances programming skills and logical thinking. It examines the impact of teaching methods on learning outcomes. Two cohorts participated: a test group using ChatGPT and a control group with traditional instruction. Pre-tests (prior knowledge), post-tests (learning outcomes), and a questionnaire (ChatGPT feedback) were used. Tests were designed by a committee of teachers and inspectors following the Tunisian computer science curriculum.

C. *Ethical Considerations*

This study ensured ethical AI use by informing students of ChatGPT's purpose, obtaining consent, and promoting critical engagement. Privacy was protected, and academic integrity upheld by discouraging plagiarism. Educators monitored interactions to foster responsible AI use in learning.

D. *Sample Characteristics*

This study compares learning outcomes between two teaching modalities among 2nd-year computer science students (aged 16–17) from three randomly selected schools. Student placement is managed by Ministry of Education software. The study covers data structures, conditional statements, and loops. T-test results (Table I) show no significant initial proficiency differences ($p = 0.071$), with Levene's test confirming group equivalence ($p = 0.507$).

TABLE I. OVERVIEW OF SAMPLE CHARACTERISTICS

Group	Performance Mean	N	Standard Deviation
Test	15.77	31	1,927
Control	14.24	33	1,621
Total	14.98	64	1,923

E. *Pre-Test*

We started with a pre-test to assess students' initial understanding of programming concepts, given their lack of prior experience, and to ensure group homogeneity, reducing teacher influence. This study involved three secondary schools, each with its own educator, but using the same instructional scenario. Student rosters were created by the school administration to ensure fair distribution based on gender and past performance. The pre-test, consisting of 20 multiple-choice questions, evaluated students' knowledge of basic programming concepts before instruction and post-test evaluation.

TABLE II. DESCRIPTIVE STATISTICS OF PRE-TEST (BY SECONDARY SCHOOLS)

Secondary school	Mean	Std. Error
Ahd EL Jadid	15.64	0.402
Avicenne	14.41	0.272
Sayeda	14.53	0.448

TABLE III. TEST OF HOMOGENEITY OF VARIANCE (INDEPENDENT VARIABLE: SECONDARY SCHOOL)

Statistic	df1	df2	Sig.
Based on Mean	2	61	**0.104**
Based on Median	2	61	0.200
Based on Trimmed Mean	2	61	0.116

TABLE IV. DESCRIPTIVE STATISTICS OF PRE-TEST (EXPERIMENTAL GROUP/CONTROL GROUP)

Group	Mean	Std. Error
Experimental	15.77	0.346
Control	14.24	0.282

TABLE V. TEST OF HOMOGENEITY OF VARIANCES (INDEPENDENT VARIABLE: EXPERIMENTAL GROUP/CONTROL GROUP)

Statistic	df1	df2	Sig.
Based on Mean	1	62	**0.507**
Based on Median	1	62	0.491
Based on Trimmed Mean	1	62	0.513

Homogeneity tests show p-values of 0.104 and 0.507, confirming homogeneity across schools and between groups.

TABLE VI. TESTS OF NORMALITY (BY SECONDARY SCHOOL)

Secondary school	Kolmogorov-Smirnova	Shapiro-Wilk
Ahd EL Jadid	0.174 (p = 0.030)	0.933 (p= 0.075)
Avicenne	0.180 (p = 0.145)	0.920 (p = 0.145)
Sayeda	0.194 (p = 0.059)	0.923 (p = 0.128)

TABLE VII. TESTS OF NORMALITY

Group	Kolmogorov-Smirnova	Shapiro-Wilk
Experimental	0.140 (p = 0.126)	0.956 (p = 0.226)
Control	0.142 (p = 0.089)	0.950 = 0.136)

Results indicate that both groups and schools exhibit normal distributions, confirming homogeneity and suggesting the groups are representative samples. The experimental group showed a higher mean with a lower standard deviation compared to the control group, though this does not affect normality.

F. *Experimental process*

The study compared two groups: one learning with ChatGPT and the other using traditional methods. Both took a pre-test, attended 20 sessions, and completed a post-test on algorithms and Python. The experimental group received personalized ChatGPT feedback and used a flipped classroom model, while the control group relied on lectures and textbooks.

G. *Post-test*

At the end of the 20 sessions, we administered a 20-question survey to 64 students: 31 in the experimental group (AI with ChatGPT) and 33 in the control group (traditional methods). The survey, created in Google Forms and approved by experienced lecturers, was completed in class. Descriptive statistics (mean, median, standard deviation) were used to summarize the data.

TABLE VIII. INDICES OF CENTRAL TENDENCY AND DISPERSION OF THE "PERFORMANCE" VARIABLE

Descriptive Statistics						
	N	*Min*	*Max*	*Mean*	*Std. Deviation*	*Variance*
Performance	64	5	17	11,91	3,235	10,467
Valid N (listwise)	64					

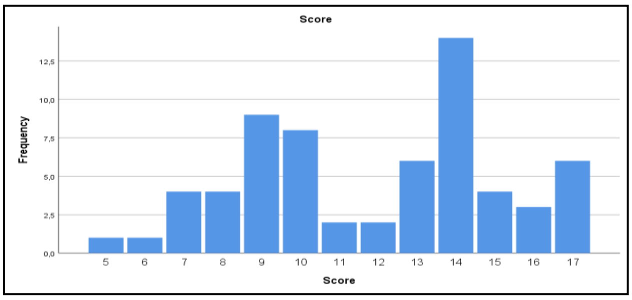

Fig. 1. Students' post-test Performance distribution

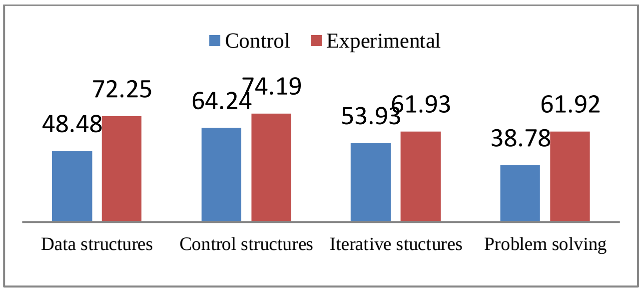

Fig. 2. Percentage of correct answers for each concept in both groups (control/experimental)

Figure 2 shows that the experimental group outperformed the control group across most concepts. For data structures, the experimental group scored 72.25% compared to 48.48% for the control. The experimental group also scored higher in control structures (74.19% vs. 64.24%) and problem-solving (61.92% vs. 38.78%), though their score in iterative structures (61.93%) was slightly lower than the control group's (53.93%).

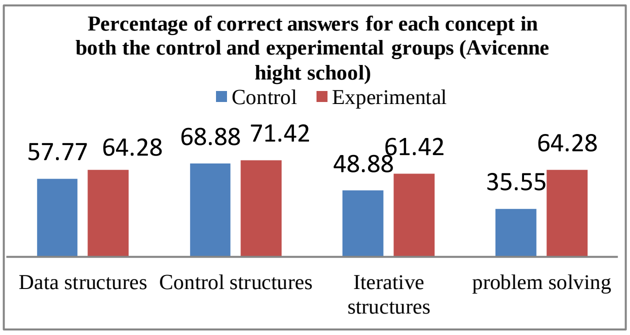

Fig. 3. Percentage of correct answers for each concept in control/experimental groups (Avicenne secondary school)

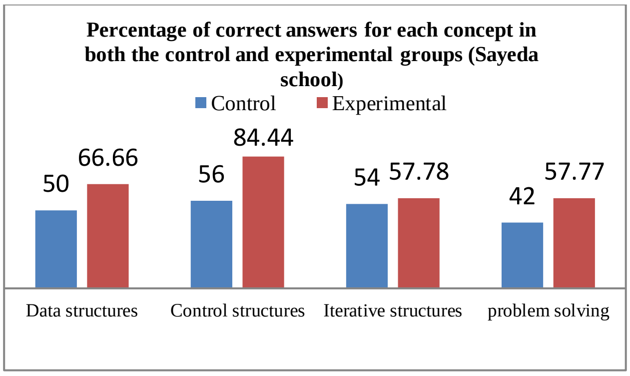

Fig. 4. Percentage of correct answers for each concept in control/experimental groups (Sayeda school)

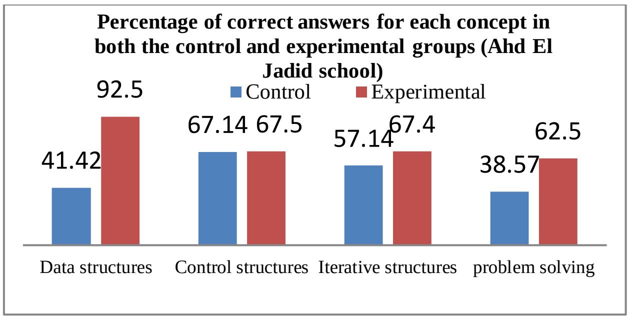

Fig. 5. Percentage of correct answers for each concept in control/experimental groups (Ahd El Jadid secondary school)

Figures 3, 4, and 5 show that experimental groups across all three schools performed better than control groups, suggesting the effectiveness of the experimental approach. However, improvements varied, indicating that factors like teaching methods and curriculum design may affect performance.

In summary, descriptive statistics show a significant difference in mean performance, with the experimental group (ChatGPT) outperforming the control group. However, to test our hypothesis about ChatGPT's impact on programming and logical thinking, we used inferential statistics. Normality testing was conducted to ensure appropriate statistical tests (Ghasemi et al., 2012).

TABLE IX. TESTS OF NORMALITY FOR THE VARIABLE "POST-TEST PERFORMANCE"

		Kolmogorov-Smirnova			Shapiro-Wilk		
	Group	*Statistic*	*df*	*Sig.*	*Statistic*	*df*	*Sig.*
Performance	*Experimental*	196	31	,004	,911	31	,014
	Control	191	33	,004	,920	33	,019

The Kolmogorov-Smirnov test yielded significance levels of 0.004 for both groups. Significantly this means there is a marked divergence from normal distribution. Observing such extreme deviations from normality by chance alone is exceptionally rare. The probability falls below the 0.05 threshold. On account of this, we reject null hypothesis of normality for both groups. Thus normality assumption is not satisfied, in this circumstance the non-parametric Mann-Whitney U test should be implemented (Hart et al., 2001).

TABLE X. INDEPENDENT-SAMPLES MANN-WHITNEY U TEST

Total N	64
Mann-Whitney U	195,500
Wilcoxon W	756,500
Test Statistic	195,500
Standard Error	73,785
Standardized Test Statistic	-4,283
Asymptotic Sig.(2-sided test)	,000

The Mann-Whitney U test provided an outcome. It detailed a test statistic of 195.500. Asymptotic significance in a two-sided test was established. It was declared as 0.000. This numeric value unveils an attribute; it is lower than the accepted level of significance which is set at 0.05. The significant statistical variation between the two groups has been unveiled. This finding leads to null hypothesis being rejected. It suggests a significant difference. This difference is between the two groups under comparative analysis.

H. Students' questionnaire

The questionnaire created using Google Forms comprises five multiple-choice questions. Its primary aim is to gather student perceptions after using ChatGPT, addressing key research inquiries and providing insights relevant to our study.

Question 1 How effective have you found using ChatGPT to learn programming?

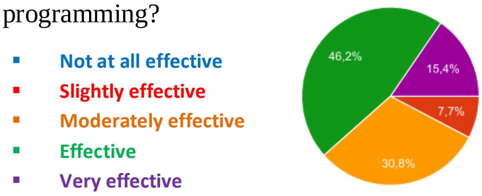

Fig. 6. Effectiveness of using ChatGPT

The data reveals an interesting finding, with 61.6% of respondents rating their experience of learning programming with ChatGPT as effective or very effective. Additionally, 30.8% classified it as moderately effective, indicating a strong overall positive response.

Question 2 What aspects of programming did you find easiest to learn with ChatGPT?

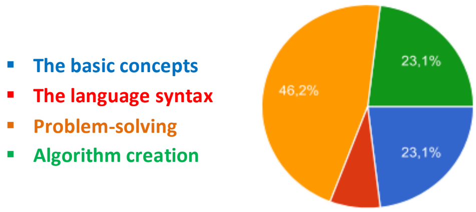

Fig. 7. Easiest aspects of learning programming with ChatGPT

Problem-solving was the easiest programming component to grasp with ChatGPT, chosen by 46.2% of participants. Basic concepts and algorithm creation were each selected by 23.1%. In contrast, only 7.7% chose language syntax, making it the least favored learning aspect.

Question 3 How much has ChatGPT improved your overall understanding of programming?

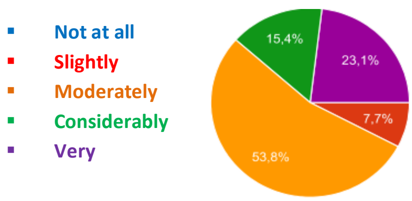

Fig. 8. Overall understanding of programming improved by ChatGPT

In summary, 92.3% of participants reported improved programming comprehension due to ChatGPT, with 23.1% finding it exceptionally beneficial. These results suggest that ChatGPT positively influences programming understanding, though with varying levels of effectiveness.

Question 4 Did you find ChatGPT useful for asking questions and getting further explanations on programming topics?

Fig. 9. Figure 11: Usefulness of ChatGPT in asking questions and getting further explanations on programming topics

Results point out ChatGPT deemed valuable resource. It assists with clarification on programming concepts.

Question 5 Do you think ChatGPT is more effective for learning programming than other traditional methods?

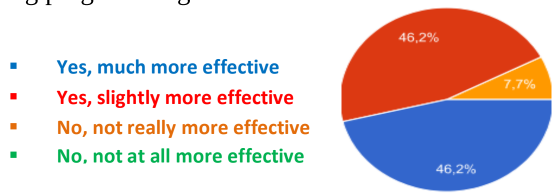

Fig. 10. Comparison of ChatGPT and traditional methods for learning programming

The positive response indicates that ChatGPT is seen as a crucial tool for learning programming, outperforming traditional methods in effectiveness. It enhances learning by providing accessible support across various concepts. Students recognized and appreciated its benefits.

IV. Results

This section presents the findings of the study, addressing the research questions posed in the introduction: (1) How does dynamic interaction with ChatGPT affect students' development of computational thinking, problem-solving skills, and their ability to transfer these to real programming scenarios? And (2) Does ChatGPT help to reduce the difficulties associated with basic programming concepts?

A. Learning Outcomes

The experimental group (ChatGPT-assisted) demonstrated significantly higher post-test performance compared to the control group (traditional instruction). Descriptive statistics revealed a mean score of 13.65 (SD = 2.76) for the experimental group versus 10.27 (SD = 2.79) for the control group (Table XI). Non-parametric analysis (Mann-Whitney U test) confirmed this disparity ($U = 195.5$, $p < 0.001$), rejecting the null hypothesis of equal performance. The concept-specific analysis (Fig. 2) highlighted ChatGPT's effectiveness in enhancing learners' performance, particularly in *problem-solving* (61.92 % vs. 38.78 % correct answers) and *data structures* (72.25 % vs. 48.48 %). Improvements were also observed in *iterative structures* (61.93 % vs. 53.93 %) and *control structures* (74.19 % vs. 64.24 %), with the experimental group consistently outperforming the control group across all areas assessed.

B. Student Feedback

Post-experiment surveys revealed strong student endorsement of ChatGPT (Fig. 10):

Effectiveness: 61.6% rated ChatGPT as "effective" or "very effective" for learning programming. Concept Mastery: 46.2% found problem-solving easiest to learn via ChatGPT, surpassing syntax (7.7%) and algorithms (23.1%).

Understanding: 92.3% reported improved comprehension, with 23.1% noting "exceptional" gains.

Preference: 76.9% deemed ChatGPT more effective than traditional methods.

V. Discussion

A. Addressing the Research Questions

a) Impact on Computational Thinking and Problem-Solving Skills

ChatGPT significantly enhances students' computational thinking and problem-solving skills. The experimental group outperformed the control group in problem-solving tasks (61.92% vs. 38.78%) and data structures (72.25% vs. 48.48%). This aligns with constructivist learning principles, where active interaction fosters knowledge construction [39]. ChatGPT's real-time explanations and tailored examples help students internalize programming concepts and apply them to practical tasks like debugging and algorithm design.

b) *Reduction of Difficulties in Basic Programming Concepts*

ChatGPT simplifies complex topics, particularly in problem-solving (46.2%) and algorithm creation (23.1%), compared to language syntax (7.7%). Additionally, 91.4% of students reported improved understanding, with 23.1% describing it as "exceptional." This highlights ChatGPT's potential to address gaps in traditional instruction [4].

B. Pedagogical Implications

ChatGPT aligns with constructivist theories, offering personalized feedback and scalable support akin to virtual teaching assistants [30]. Its ability to generate real-world examples and debug code in real-time complements traditional methods, particularly in areas where students struggle.

C. Contextual Challenges and Limitations

Variability in performance across schools suggests factors like teacher adaptability and infrastructure influence outcomes. Technical barriers, such as internet dependency, pose equity concerns, and ChatGPT's text-based format may limit its effectiveness in teaching iterative structures.

D. Future Directions

Long-Term Retention and Transferability: Explore ChatGPT's long-term impact on complex tasks like software development.

Ethical Integration and Critical Thinking: Balance AI assistance with opportunities for self-directed learning.

Scalability and Accessibility: Develop offline AI models and training programs for educators.

E. Policy Recommendations

Integrating ChatGPT into Tunisia's curriculum could address gaps in programming education. Investments in teacher training and infrastructure are essential for equitable access.

VI. Conclusion

This study demonstrates that ChatGPT significantly enhances programming education by improving computational thinking, problem-solving skills, and the understanding of basic programming concepts. Its interactive and personalized approach addresses key challenges in traditional instruction, making it a valuable tool for educators and policymakers in Tunisia and beyond. However, successful integration requires careful consideration of contextual factors, ethical implications, and infrastructure limitations.

By leveraging ChatGPT's strengths while addressing its limitations, educators can create more engaging and effective learning environments that prepare students for the demands of the digital age. Future research should build on these findings to explore long-term impacts, scalability, and the role of AI in fostering critical thinking and innovation in education.

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