Article

ChatGPT: Impact on programming learning among students at the Technological University of Huasteca Hidalguense

ChatGPT: ¡Impacto en el aprendizaje de la programación en los estudiantes de la Universidad Tecnológica de la Huasteca Hidalguense

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Abstract

The emergence of generative AI in education has a revolutionary impact, which moves teaching-learning processes to change, thus requiring teachers and students to learn new skills to e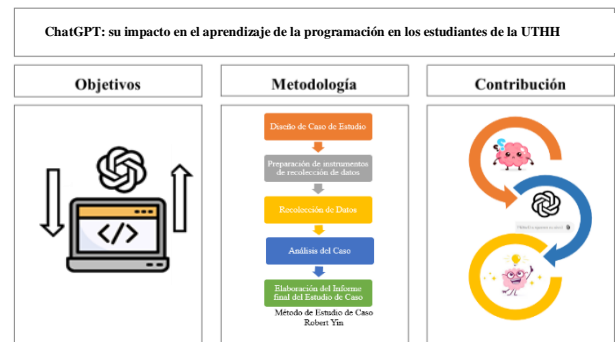nhance their use in such a way that it favors meaningful learning. This research focused on knowing the impact of its use on the learning of programming in UTHH students; The Case Study Method proposed by Robert Yin was used. The analysis of the results does not lead to the conclusion that students strengthen the learning process through requesting guidance and correction on errors in the code, detailed explanation of the lines of code to ChatGPT, highlighting the fact that it can be used natural language for communication, which helps them better understand the problems raised.
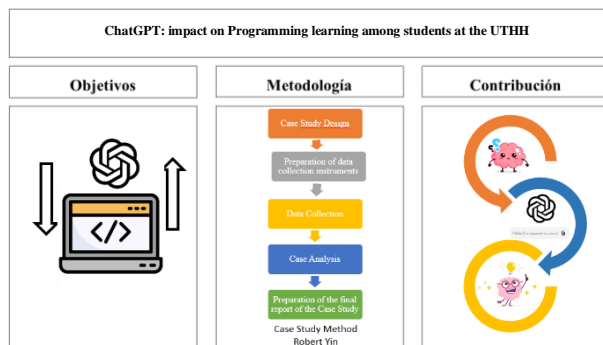
ChatGPT, Learning, Programming

Resumen

La irrupción de la IA generativa en la educación tiene un impacto revolucionario, que mueve a cambiar los procesos de enseñanza – aprendizaje, así exige a docentes y estudiantes aprender nuevas habilidades para potencializar su uso de tal forma que favorezca al aprendizaje significativo. Esta investigación se centró en conocer el impacto de su uso, en el aprendizaje de la programación en los estudiantes de la UTHH; se utilizó el Método de Estudio de Caso propuesto por Robert Yin. El análisis de los resultados nos lleva a concluir que los estudiantes fortalecen el proceso de aprendizaje a través de solicitar orientación y corrección sobre los errores en el código, la explicación detallada de las líneas de código al ChatGPT, resaltando el hecho de que se pueda usar el lenguaje natural para la comunicación, que les ayude a una mejor comprensión de los problemas planteados.
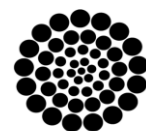

ChatGPT, Aprendizaje, Programación

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Introduction

Artificial intelligence (AI) is a branch of computing based on expert systems, meaning that algorithms have "a power of decision", based on millions of established rules. For Turing "... any system capable of imitating human intelligence is considered artificially intelligent..." (Kunjuk, 2024).

This is particularly evident when the design of these AI systems replicates an interactive conversation, matching human behaviour. It was in 1950 when Alan Turing published the article "Computing Machinery and Intelligence", where he proposed the Turing Test to assess the ability of a machine to have human behaviour, in 1956 the term "artificial intelligence" was coined for the first time during the Dartmount conference.

It took seven decades for Turing's ideas to come to life in an accessible and massive way through the proposals of various technology giants, some of these are: chatGPT, ChatSonic, Claude, Copilot, Gemini, JasperChat, Poe AI, YouChat, among others (Expansión, 2024). In this journey of AI integrating into everyday life, several types are identified. Each subset of AI requires a unique combination of hardware, software and security depending on the end goal of the project, a classification is listed below:

- Classical Machine Learning (ML): Uses models or algorithms to analyse data sets, identify patterns and make predictions without human intervention.
- Deep learning: Makes use of models that can recognise complex patterns in images, text, sounds and other data to produce accurate information and predictions. This type of AI is an advance on classical ML.
- Computer vision: Trains computers to understand the overwhelming amount of visual data that is collected to locate, identify and track specific objects or actions.
- Generative AI: Generative AI creates new content based on the massive data sets and machine learning AI algorithms it was trained on. This type of AI is integrated with language AI, also known as natural language processing (NLP), which allows it to process and understand human language (INTEL, 2024).

According to the article "Microsoft Copilot vs. ChatGPT vs. Gemini: Which One is the Best AI Chatbot?" recently conducted by DynaTech Systems (DynaTech Systems, 2024), these are the three most demanded options, and Table 1 highlights some statistics on their use, although the exact number of subscribers is not known for reasons of commercial strategies.

Box 1
Table 1

Statistics at a glance

Copilot	ChatGPT	Gemini
70% of Copilot users indicate that they are more productive, and 68% mention that it impacts the quality of their work. 77% of users once they have used Copilot, they don't want to stop. 64% say that Copilot helps them reduce the time they spend on their activities.	ChatGPT has up to 200 million monthly active users around the world. 77.2 million people are located in the US. The ChatGPT Plus version has around 3.9 million subscribers in the US.	Gemini has around 1 billion users worldwide. Gemini is available in 46 languages, including Chinese, German, Arabic, Spanish, Hindi, etc. Gemini has around 330.9 million monthly visits.

Source: DynaTech (2024)

Table 2 shows a summary of the main features of the three most demanded generative AI proposals, where it can be highlighted that Copilot and Gemini, being subscription products, their use is restricted, on the other hand, ChatGPT offers a free version which favours its use.

Box 2
Table 2

Comparison of Copilot, ChatGPT and Gemini

Criterio	Copilot	ChatGPT	Gemini
Company Year of launch Language model	Microsoft 2023 Based on GPT-4 (from OpenAI)	OpenAI 2022 GPT-3.5 / GPT-4	Google 2023 Gemini (Based on PaLM 2)
Integration	Office 365, GitHub	OpenAI API, various platforms	Google Workspace, Google Assistant
Multilanguage	Yes	Yes	Yes
Year of access to information	Until 2021 (by OpenAI GPT-4)	Until 2021 (GPT-3.5) / 2024 (GPT-4 Turbo)	Until 2023 (upgraded)
Generate images	No	Yes (with DALL-E in GPT-4)	Yes (integrated with Google tools)
Costs	Subscription-based	Subscription based, limited free version	Subscription based, integrated with Google services
Programming support	Extensive, integrated with GitHub and VSCode	Basic	Basic

Source: DynaTech (2024)

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https://doi.org/10.35429/JPD.2024.8.19.1.10

This availability of AI tools for students and teachers generates a new scenario in the teaching-learning process. As they point out in the experimental comparative study of the use of chatGPT and its influence on student learning in the Information Technologies degree programme at the University of Guayaquil, the researchers argue that 'The results suggest that the use of ChatGPT can be an effective didactic strategy to improve the academic performance of students'.

While AI offers opportunities to support teachers in their educational and pedagogical responsibilities, human interaction and collaboration between teachers and learners must remain central to education.

AI has become ubiquitous in education, it can be used by teachers to alter the teaching and learning experience, helping teachers to create instructional content; it can impact the student experience by improving learning outcomes through personalisation.

Advances in AI have generated debates about meaningful learning for students, i.e. building the mental scaffolding Ausubel refers to, 'The most important factor influencing learning is what the learner already knows...', however, the reliance on AI has led to a reliance on the use of AI as a learning tool. However, the dependence on AI to generate answers to students' tasks can cause them to lose important skills and, above all, the construction of their own knowledge and its socialisation.

Universities around the world have the mission to educate and offer students new ways of thinking, of solving problems, of rethinking proposals, and at the same time they must assimilate the knowledge and skills for their insertion in the productive sector.

AI has the potential to revolutionise the teaching-learning process, so students - who will be integrated into an AI-driven workforce and digital economy - cannot be left adrift in their adoption of these academic training alternatives that will allow them to better prepare for an evolving technology-based future.

One potential of AI that should be kept in mind is the fact that personalisation of learning, by giving personalised recommendations on what can be optimally adapted to the speed and level of difficulty required by the learner, can help them improve their academic performance, both in and out of the classroom. UNESCO identifies five areas for AI application:

- In the service of education management and implementation;
- In the service of teacher empowerment and teaching;
- In the service of learning and the assessment of results;
- In the service of developing the values and competencies needed for life and work in the AI era; and
- As a way of providing lifelong learning opportunities for all.

With all these benefits, there are also some challenges, one of the main ones being the lack of training and knowledge of teachers on how to use AI effectively in the classroom; on the students' side they run the risk of minimising critical, reflective and creative knowledge creation processes, which can bring unimaginable consequences in the cognitive process derived from the artificial development of content.

And this is where, from the particular point of view of this team of researchers, the central point of this research is found, the non-production of new knowledge by the students, by leaving to the AI the task of their responsibilities and cognitive effort that represents for each of the learning activities, additionally the decrease of collaborative learning - given the individualisation that is generated with the use of AI - and the socialisation of knowledge, interaction and human relations; privacy and data security, ethics and copyright, whose is it the student or the AI? 'the dangers of digitisation, virtualisation and artificialisation of learning can have negative consequences for the quality of educational assessment'. However, learning to program requires a series of analytical thinking skills, logical and algorithmic reasoning, as well as a high tolerance to frustration, tenacity and constancy to achieve the objectives, the development of these skills positively affects the academic performance of students and their personal development, additionally students also learn how technology works and how they can use it.

The increase of programming languages and tools has helped students to learn, learning platforms such as Codecademy, Udemy, Platzi, Coursera among others, offer a wide variety of alternative programming courses with different levels of complexity that promote self-learning with 7x24 availability; on the other hand, there are also several programming tools, such as Scratch, Alice, Code, Blockly, Code. org, App Inventor, Micro:bit, Greenfoot, Logo, Codecademy, Thimble, Lightbot, Tynker, Blockly Games, App Lab, Snap! CodeCombat, MakeCode, Swift Playgrounds, Repl.it and Unity among others, these programming tools and environments are designed to help students learn programming concepts in a fun and engaging way.

ChatGPT is completely different from programming tools and environments as it is an AI model and makes use of natural language, allowing even people without programming skills to easily solve programming problems.

During learning programming, students use development environments, which may have AI extensions such as Copilot, ChatGPT - Genie AI, among others, also integrate libraries and / or specific components of the development language in question and requires programming knowledge of the language syntax, ChatGPT does not require knowledge of the syntax or specific knowledge of a programming language, since the interaction is conversational so the learning approach is completely different for both students and teachers.

While there are many advantages for students in terms of learning programming, there are also limitations, this research focuses on examining the opinion of the use of ChatGPT in the learning process of programming in students of the Universidad Tecnológica de la Huasteca Hidalguense, knowing their point of view, will provide teachers with valuable information on how to approach and integrate AI tools in the teaching process of programming. Two research questions were posed:

1.   what is the opinion of UTHH programming students on the advantages of using ChatGPT in the programming learning process?
2.   What is the students' opinion about the disadvantages of using ChatGPT in the programming learning process?

Methodology

This study examines the opinions of students who use ChatGPT tool for learning programming. It makes use of the case study method proposed by Robert K. Yin, who posits it as a strategy that seeks to understand a complex phenomenon especially when the boundaries between the phenomenon and the context are not clearly defined.

Yin's proposed characteristics:

Focus on context: refers to studying a phenomenon within its context.

Multiple or single case research: Yin proposes that case studies can involve one or several cases.

Variety of data sources: Case studies rely on multiple sources of evidence, such as interviews, surveys, observations, documents among others.

Research design: The design of a case study should consider five main components: Research questions.

-     Propositions (or theories) guiding the study.

-     Unit of analysis (what or who is the 'case').

-     Logic linking the data to the propositions.

-     Criteria for interpreting the findings.

Data analysis strategies: emphasises the importance of using strategies to analyse the data. Analytical generalisation: reflecting on findings from one case can be applied to a broader theory.

Contextual approach

This study aimed to examine students' opinions regarding the use of ChatGPT in learning programming in the subject Programming Methodology of the first term of TSU in Information Technology at the Universidad Tecnológica de la Huasteca Hidalguense (UTHH) in the course Sep-Dec 2023.

Both quantitative and qualitative research approaches were used in the study. A questionnaire was designed to collect quantitative data and a form consisting of open-ended questions to obtain qualitative data.

The contextual approach focusing on these features will allow for an in-depth exploration of how a tool such as ChatGPT suits the needs of learners in an early academic programming environment and how it contributes to their learning process.

Sixty-five students from the first semester of Programming Methodology at UTHH participated in the research. The study group included 14 females and 51 males, who voluntarily participated by answering the questionnaire provided.

The ages ranged from 18 to 25 years old. The students who participated in the research have minimal programming experience. As part of the research process ChatGPT was integrated into the course, the course sessions were held for three 2-hour sessions per week, for 14 weeks.

The teaching strategy was oriented to Problem Based Learning (PBL), since it sought to encourage an active role of the student, both in the analysis, the development proposal and the validation of results of the algorithms requested.

The sessions were planned in three moments, the initial moment to activate previous knowledge by explaining the theoretical and practical concepts, also supported by presentations, e-books and of course ChatGPT, this dynamic promoted a directed use of ChatGPT to clarify doubts, compare solutions and reflect on the results obtained by the chat. During the development phase, the problem statement is made, students are asked to make their proposed solution independently and without the help of ChatGPT, the progress is observed and common errors are identified and these are asked to ChatGPT, to provide a solution; On the other hand, students who complete the task correctly, ask ChatGPT to offer alternatives to improve the given solution; for the Closing process, the correct solution of the proposed algorithm is observed and the options and answers given by ChatGPT are reflected upon, students highlight the mistakes they made, or the areas of improvement that can be implemented.

To carry out the data collection process, a questionnaire of closed and open questions was used through a form designed by the research group. The questionnaire and the questions of the form were designed according to a literature review and validated with three experts in the field of educational technology and three experts in the area of programming.

The structure of the questionnaire consisted of the following areas:

-   Demographic context: which considered age, gender and level of previous programming experience.

-   Focus of ChatGPT use: here a list of possible uses and how it supports learning was given.

-   Impact on learning: focused on questions about the appropriation of knowledge and the quality of the knowledge.

-   Accuracy of results: this included questions about whether the tool provides correct results.
-   In order to get the students' point of view on the use of ChatGPT, three questions were asked:

What positive aspects would you highlight from the use of ChatGPT in your programming learning, what negative aspects or limitations have you found when using ChatGPT in your programming learning, do you have any suggestions for improving the use of ChatGPT in programming learning, and do you have any suggestions for improving the use of ChatGPT in programming learning?

The questionnaire was designed in Google Forms for data collection, they were provided with the link to the form and asked to respond to it.

Quantitative data was obtained from the 65 students, analysis of the data revealed significant patterns in their responses, which were examined in detail by the researchers. This quantitative analysis was complemented by a qualitative analysis of the views expressed by the students, allowing a deeper understanding of their experiences, perspectives and attitudes towards the use of ChatGPT in learning programming.

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Furthermore, the qualitative analysis based on the responses to the open-ended questions provided a framework for identifying commonalities as well as divergences in opinions. The active participation of the researchers ensures validity, reliability and an overview of the study group regarding the impact of ChatGPT on their learning process.

Results

Students' opinions about their use of ChatGPT in the learning process of programming were analysed. Emphasis was given to the use they can make of it with respect to learning, as shown in Table 3, then the perception regarding how it helps in their learning, the practice of copy and paste, as well as the quality part of the answers are documented in percentage form.

Box 3

Table 3

Student use of ChatGPT

Use	Number of students	Porcentage
Ask questions about theoretical concepts	39	60.0
Get detailed explanations of code	49	75.3
Ask for help debugging code	22	33.8
Generate code samples to study	24	36.9
Ask for suggestions on best programming practices	29	44.6
Solve concrete algorithm problems	20	30.7
Learn new technologies and programming languages	27	41.5
Ask for explanation in natural language to help understanding of the subject, prior information needed for the coding process	45	69.2
Ask for clarification and correction when there are errors in the code or the results are not as expected.	52	80.0

Source: Own elaboration

This data gives a picture that while students are clear about how the learning process can be aided by asking for guidance and correction of errors in the code, the detailed explanation of the lines of code and highlights the fact that natural language can be used to achieve understanding of the topic - i.e. analysis of the problem - before coding.

These practices have an impact on the learning of programming, so the following results are observed in the quantitative analysis:

Box 4

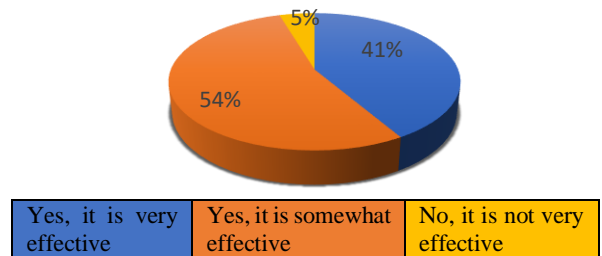Do you consider ChatGPT to be an effective tool for learning to program?

Yes, it is very effective	Yes, it is somewhat effective	No, it is not very effective

Figure 1

Distribution of usage for learning to program.

Source: Own elaboration

It can be seen that 54%, i.e. just over half of the students consider ChatGPT to be a moderately effective tool for learning to program.

Box 5

Do you find that using ChatGPT helps you to better understand programming concepts?

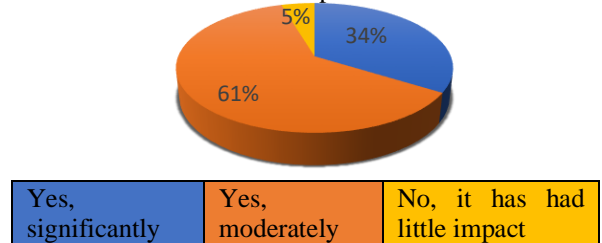| Yes, significantly	Yes, moderately	No, it has had little impact

Figure 2

Distribution of impact on understanding.

Source: Own elaboration

61% of the students agree that the tool helps them to better understand programming concepts.

Box 6

When you use ChatGPT, do you consider that you learn to solve programming problems by yourself or do you simply copy the solutions?

I learn to solve problems	A combination of both	I copy the solutions
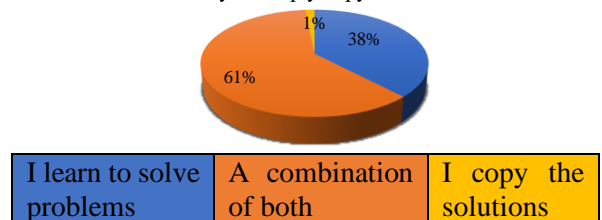
Figure 3

Distribution of impact on skill development

Source: Own elaboration

Felipe-Redondo, Ana María, Del Carmen-Morales, Yucels Anaí, Del Carmen Morales, Heidi and Nuñez-Cárdenas, Felipe de Jesús. [2024]. ChatGPT: Impact on programming learning among students at the Technological University of Huasteca Hidalguense. Journal Practical Didactics. 8[19]1-10: e3819110.
https://doi.org/10.35429/JPD.2024.8.19.1.10

61% mention that they do a combination of their own learning and the practice of copying solutions.

Do you think that using ChatGPT has improved your ability to think critically and solve problems on your own?
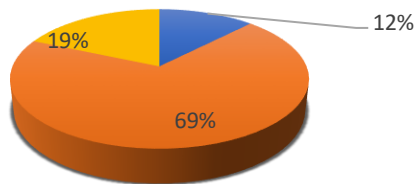
| Yes significantly | Yes, moderately | No, it has had no impact |

Figure 4

Distribution of usage for learning to program

Source: Own elaboration

Students consider that the use of ChatGPT has improved their ability to think critically and solve problems on their own,

Regarding the advantages of using ChatGPT to promote learning programming to students, there were 4 main advantages, shown in Table 4.

Table 4

Coincident Benefits Concentrate

Coinciding Advantages	# Students
Explanation of the code	18
Minimise time for bug fixes	22
Learning new programming languages or frameworks	12
Optimise code or suggestions on best programming practices	13
Total	65

Source: Own elaboration

Some of the students' opinions are:

"Sometimes I understand the codes better with the explanation you provide".

"It helps to explain in detail if you indicate it".

"It has helped me to solve problems quickly, this is summarised in a significant time saving and allows me to move forward with greater speed in my work".

"That you don't just give code for the sake of giving it, but that there is a reason, an explanation as to why that code."

"Decrease in learning time by not having to search in different sources, plus it gives you current solutions and not the articles or videos from years ago, plus it helps to better understand the documentation in some aspects that become complicated."

"It offers useful and fresh alternatives when I can no longer find solutions in traditional places like Stack Overflow or in the official documentation"

"Time saving and better understanding, as you can explain the code step by step and get to know how everything works."

"The way of explanation can be in such a basic way that one manages to understand it."

"Many students are able to ask questions that they don't ask in class, because they are afraid or embarrassed to talk".

With respect to the disadvantages of using ChatGPT to promote the learning of programming to students, 4 fundamental disadvantages were agreed upon, as well as there were students who stated that they did not find any disadvantage in its use.

The results are summarised in Table 5.

Table 5

Concentration of Coincident Disadvantages

Disadvantages Coincident	# Students
Dependence on use to carry out activities	14
Copy paste	9
Incorrect or out-of-context answers	17
Solutions deviate from a logic of their own	14
I find no disadvantages	11
Total	65

Source: Own elaboration

Felipe-Redondo, Ana María, Del Carmen-Morales, Yucels Anaí, Del Carmen Morales, Heidi and Nuñez-Cárdenas, Felipe de Jesús. [2024]. ChatGPT: Impact on programming learning among students at the Technological University of Huasteca Hidalguense. Journal Practical Didactics. 8[19]1-10: e3819110.
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Some of the students' opinions are:

"I don't think so much at the moment, but a few months ago I realised that I was relying on it a lot for development".

"It provides code without the need for research, which doesn't help a programmer to develop their skills."

"That it doesn't allow autonomous learning, it doesn't make me think about problem solving at all."

"That I don't have the confidence to think that my code is OK"

"If you don't learn the basics of programming and above all logic, chatting is useless, because you yourself will have no idea what you want to do and you will just copy for the sake of copying".

"Irresponsible use, just getting information to copy and paste into a paper".

"It limits us as learners to face challenges, understanding of programming and relying on it for problem solving without understanding."

"Sometimes chatgpt does not fully understand the context or the question, which gives inaccurate answers."

"It prevents us from looking for solutions based on our own logic."

"That if you don't know what you want or are unclear, it gives ambiguous and mostly wrong answers."

"The negative thing would be that you lose the habit of researching elsewhere on the internet or even the official documentation of a framework is no longer read so thoroughly because you solve your doubts with the AI."

Conclusions

The purpose of this research was to find out the impact of the use of ChatGPT on students who are learning programming. Most of the students agree that ChatGPT offers them advantages, they also recognise the limitations or risk of its use and the impact on their learning process.

The use of ChatGPT is oriented to the explanation of the code that helps them to understand it better, to solve problems or errors, to optimise the code already generated or to learn a new development technology.

One aspect to highlight is the fact that the students value the quick answers, but they also point out as a disadvantage the effectiveness of the answer, although this fact can be related to the approach, the description of the context or the structure of the question, they also highlight the lack of updated information or questions to data sources not available in the free version.

What is most striking to the group of researchers is the recognition of the dependence that can be generated among students to solve their assignments and abuse of copy paste.

While most of the participants in the study acknowledged that they use ChatGPT to better understand the process of programming logic and to apply this logic and sequence of thought in the actual posing of questions to make the solutions effective, on the contrary, those who perceive that ChatGPT affects their thinking skills because a correctly posed question is enough and the solution is given, no longer carry out this process.

To minimise this impact, which can have serious consequences on the natural process of analysis for solving algorithms, it is essential that as teachers we rethink the use of ChatGPT by moving towards projects that promote thinking skills (computational thinking, creativity, algorithmic thinking, socialisation of learning, critical thinking and problem solving), critical thinking and problem solving), understanding that the chat is only an 'auxiliary in the learning process of concepts and practices related to the PC, allowing the generation of virtuous cycles, through which the learner of this subject can use this type of tool to increase the pace and quality of acquisition of new skills'.

Declarations

Conflict of interest

The authors declare that they have no conflicts of interest. They have no known competing financial interests or personal relationships that might have appeared to influence the article.

Felipe-Redondo, Ana María, Del Carmen-Morales, Yucels Anaí, Del Carmen Morales, Heidi and Nuñez-Cárdenas, Felipe de Jesús. [2024]. ChatGPT: Impact on programming learning among students at the Technological University of Huasteca Hidalguense. Journal Practical Didactics. 8[19]1-10: e3819110.
https://doi.org/10.35429/JPD.2024.8.19.1.10

Authors' contribution

Felipe-Redondo, Ana María: Contributed to the research idea, the design of the data collection instrument and data analysis, as well as teaching the study groups.

Del Carmen-Morales, Yucels Anaí: Contributed to the design of the data collection instrument and data analysis.

Del Carmen-Morales, Heidi: Contributed to the design of the data collection instrument and data analysis.

Núñez-Cárdenas, Felipe de Jesús: Contributed to the design of the data collection instrument and its analysis. As an external teacher, but a specialist in programming, his opinions strengthened the objectivity of the analysis.

Availability of data and materials

The data collected are available for consultation, upon request to the author of the correspondence.

Funding

Acknowledgements

Abbreviations

ABP	Problem Based Learning
IA	Artificial Intelligence
ML	Classical Machine Learning
PNL	Natural Language Processing
UTHH	Technological University of Huasteca Hidalguense

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