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Adoption and Impact of ChatGPT in Computer Science Education: A Case Study on a Database Administration Course

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Abstract: The irruption of GenAI such as ChatGPT has changed the educational landscape. Therefore, methodological guidelines and more empirical experiences are needed to better understand these tools and know how to use them to their fullest potential. This contribution presents an exploratory and correlational study conducted with 37 computer science students who used ChatGPT as a support tool to learn database administration. The article addresses three questions: The first one explores the degree of use of ChatGPT among computer science students to learn database administration, the second one explores the profile of students who get the most out of tools like ChatGPT to deal with database administration activities, and the third one explores how the utilization of ChatGPT can impact in academic performance. To empirically shed light on these questions the student's grades and a comprehensive questionnaire were employed as research instruments. The obtained results indicate that traditional learning resources, such as teacher's explanations and student's reports, were widely used and correlated positively with student's grades. The usage and perceived utility of ChatGPT were moderate, but positive correlations between students' grades and ChatGPT usage were found. Indeed, a significantly higher use of this tool was identified among the group of outstanding students. This indicate that high-performing students are the ones who are using ChatGPT the most. So, a new digital trench could be rising between these students and those with a lower degree of fundamentals and worse prompting skills, who may not take advantage of all the ChatGPT possibilities.

Keywords: educational technologies; ChatGPT; GenAI

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1. Introduction

Students are increasingly familiar with many Generative Artificial Intelligence (GenAI) tools and use them regularly. Some teachers tend to see it as a problem, because students have in their hands a tool that has the potential to create content that often they would not. Those teachers take for granted that their students will use it to cheat. The goal of studies like the one presented in this article is to change this mindset and test the use of GenAI tools to enhance the learning experience.

A remarkable quantity of sources, from renowned universities to international institutions, are providing a set of recommendations for teachers and students to get along with this embracement process. Chronologically ordered, some of the most relevant are [1] and a white paper [2], considered foundational for many of the following works. This is followed by [2] or [3], applied by [4,5] in the Spanish ecosystem, or [6]. And especially, the UNESCO recommendations guide [7], a new EDUCAUSE guide more oriented to GenAI [8], the work from [9], or Russell Group recommendations [10]. A recent compilation of studies in which ChatGPT and other GenAIs appear as new approaches for different educational purposes is shown in [11].

The next two subsections offer a summary of recommendations for using GenAI tools. The third subsection presents the related works that explore the usage of GenAI in computer science education, and more specifically, in database administration education. The last subsection introduces the present work and the posed research questions.

1.1. Recommendations for Students

Students use GenAI tools. In spring 2023, 27% of students were using AI writing tools, and by the fall, that percentage had jumped to 49%, despite some applied restrictions [12]. It is important to understand these tools, know how far they can go, and integrate them into teaching and research effectively, responsibly, and ethically. That said, the most important recommendations for students can be listed as follows:

- Know and respect the regulations [2,5–7].
- Focus on learning objectives: GenAI is a tool, not an end [2,7].
- Use the GenAI: Now is the time to learn and experiment with how to use a GenAI tool correctly [8]. For example, as a writing assistant, as a programming assistant, or as a teacher, by running a conversation in Socratic mode [4,9,10]. But, it is important to be aware of the inherent risks of using GenAIs, such as uploading personal information, especially as stated by the UNESCO recommendations guide [7]. However, the biggest risk is to use the answer that GenAI returns in the first iteration, instead of offering a personal sieve and appealing to the critical spirit of the student. [2].

Finally, whenever GenAI has been used to perform work, it is recommended to declare it like any other bibliography, such as what prompts were used and how the answers were processed [7,10].

1.2. Recommendations for Teachers

When teachers use GenAI to their advantage and use it with proper precautions, their teaching can be much more effective, reducing the time spent on a multitude of tedious tasks in order to focus on the important ones [11]. All the recommendations split their applications into the purely teaching and evaluation areas.

In the area of teaching, the recommendations emphasize providing rules and guides from the beginning of the course [2]. While also keeping the focus on learning objectives, they promote using GenAI in a number of tasks (e.g., creating learning materials or designing a class, syllabus, or topic) [7]. Moreover, certain GenAI can detect student profiles based on their performance, interests, and abilities to generate exclusive, interactive, and personalized content [2,8,10]. Another suggested goal is to develop a collaborative learning experience between teachers and students regarding how to use GenAI [8]. Involving the students in this process will increase the motivation of all players along the way [7]. Other ways of animating learning could be to apply problem-based or challenge-based learning in scenarios determined by GenAI, or to suggest prompts that end up challenging students to discover the limits of their knowledge, thus appealing to the development of their critical thinking [1,2,8].

In terms of assessment, a conventional methodology, entailing the submission of written assignments by students as homework, is an area in which AI is poised to excel [5,6]. Consequently, educators must prioritize the delineation of the specific learning outcomes they seek to achieve, whether it be a conceptual understanding, a skill, or a discrete competency. Exploring the student thinking process path could be increasingly important [10]. Furthermore, GenAIs can help teachers to do their jobs much more effectively by aiding them in rubric generation for an assessment; providing quizzes in several formats; contributing to the automatic correction of exercises, even those with elaborated answers; or by providing quick feedback paths to students on their work, automated to some extent and customized with the right GenAI training [2,7,12]. It is therefore necessary to innovate the assessments and the process, the format, and the feedback that teachers can offer to students [5].

1.3. Database Administration teaching with GenAIs

GenAI is a tool that acts as a disruptive influence on data management. Ref. [13] points out that it will impact this area in two ways.First, several hard database problems such as entity resolution, schema matching, data discovery, and query synthesis can be approached in a new way as the semantics of the data are out of the scope of automation. Thus, Large Language Models (LLMs) can aid in transforming database tuples, schemes, and queries in real-world concepts. Secondly, these question-answering tools provide a real connection to predictive and information retrieval models.

Exploring the use of AI in teaching for acquiring Database Administration (DBA) skills is not new. Twenty years ago, [14] reported, for instance, a case in which the students were impelled to create a proprietary search engine using two available tools in a semester course. After all these years, we can find works like [15], which discusses the design process used in a graduate-level U.S. University advanced data analytics course including AI, focusing a part of its study on understanding AI's impact on the accounting profession. The application of AI software (MindBridge) to the analysis of accounting data enabled the evaluation of risk, resulting in a 159% increase in the mindset mean from no knowledge at the outset of the course to average awareness at its conclusion. This outcome provides compelling evidence of student learning that is aligned with the learning objectives.

Focusing on the use of GenAI in software engineering, Ref. [16] provides a literature review in which up to 78 research questions were identified, showing the use of GenAI in a wide range of software development activities from design to education, but acknowledging the lack of research to explore the next steps. The collected experiences are related to the use of chatbots to assist this study, as well as the automation of assessments to provide the students with immediate feedback.

There is an increasing number of papers discussing the possible use of GenAI in software engineering, although tests with students are still taking off. One important conclusion is that ChatGPT may enhance student programming self-efficacy and motivation, and the teachers must teach how to properly use it through prompt-writing skills [17]. The results of [18] in a survey of 430 computer science Master Sc students suggest that many of them are familiar with ChatGPT but do not regularly use it for academic purposes, being skeptical of its positive impacts on learning unless guidelines and education on the tool is provided.

A teacher's survey contextualized in nine courses at Univ. South-Eastern Norway can be seen in [19]. Three categories were explored: theory courses, programming courses (including DBA), and project-based courses. It was demonstrated that while GenAI tools can provide guidance on programming concepts to an extent, students cannot fully develop their practical skills by using ChatGPT, especially those related to complex programming concepts or intricate problems like integrating libraries, specific system configurations, or large software systems. As some of the solutions provided by ChatGPT are outdated, it becomes clear that teacher assistance is highly desirable in combination with ChatGPT usage.

Scarce and shy trials including GenAI tools in higher education DBA courses have appeared. The University of Virginia has published a series of courses that illustrate the potential applications of artificial intelligence (AI) in the classroom, particularly in the context of learning statistics and data science [20]. Despite it being wonderful material, no results about their application have been shared yet. There are some studies focused on how to teach SQL with ChatGPT. Ref. [21] at UNIR, a Spanish university, shows the use of a chatbot-based learning platform (based on IBM Watson) to iteratively assist students to perform SQL queries. Their results show that students who used the chatbot performed better on the final SQL exam (43% pass) than those who did not (18%). Interestingly, lecturers obtain illuminating metrics on student performance at the same time. Ref. [22], in a work in progress, are using ChatGPT for a similar purpose, but they have not yet reported concrete results.

1.4. Introducing This Work

In consideration of the aforementioned findings and previous efforts, we have undertaken an empirical study. This study has an exploratory correlational nature and uses the Technology Acceptance Model (TAM) as a conceptual framework [23]. This model has been largely used in the last decades to analyze the acceptance of technologies [24] and serves to explore how the perceived usefulness and perceived ease of use affect the actual use of a technology (see Figure 1).

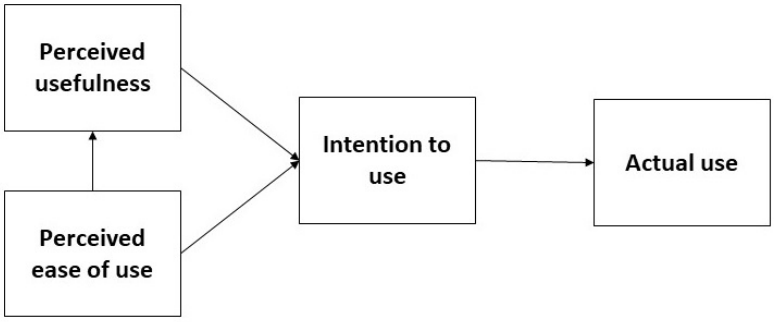

Figure 1. Technology acceptance model, adapted from [24].

The present paper addresses three research questions (RQs), the first two of which are inspired by the TAM model:

- RQ1. Is the use of ChatGPT perceived as a valuable tool among computer science students for learning database administration?
- RQ2. What computer science students' profiles are more likely to be successful users of ChatGPT to learn database administration?
- RQ3. Might the utilization of ChatGPT impact the academic performance of computer science students who are learning database administration?

This study aims to push forward the experience of using GenAIs in teaching computer science, and more specifically database administration, following the previously described set of recommendations. The rest of the article is structured as follows. The materials and methods are described in Section 2. The results are presented and discussed, respectively, in Sections 3 and 4. Lastly, Section 5 presents the conclusions, limitations, and future work drawn from this study.

2. Materials and Methods

2.1. Context

This case study was carried out in a database administration (DBA) course. The course is part of the fifth semester of the bachelor's degree in Technologies for the Information Society delivered by the Faculty of Computer Systems Engineering of the Universidad Politécnica de Madrid (UPM), located in Spain. This course is mandatory and accounts for six European Credit Transfer System credits (ECTS), equivalent to 150–180 h of student work. The course deals with traditional database administration topics such as hardware configuration to storage databases, and database optimization, security, restoration, or monitoring. Although the participating students have previously taken a generic course on databases, these topics were completely new to the students, so they had no prior knowledge of the subject. During the course, the students work in groups to perform a practical computer assignment. The case study presented in this paper is focused on the utilization and perceived utility of the resources employed by the participating students to complete the practical computer assignment as well as its corresponding individual exam.

2.2. Sample

The sample compromises 37 students enrolled in the DBA course during the academic year 2023–2024 who completed the practical assignment and the individual exam. They

were 30 males (81%) and 7 females (19%), and the mean age was 21.54 with a standard deviation of 1.73. Regarding attendance, 22 students (60%) declared that they attended all of the practical classes, 12 declared that they attended most of the classes (32%), and 3 declared that they only attended some of the classes (8%). It should be emphasized that students who had failed the DBA course the previous year were excluded from this case study to ensure that the students in the sample had no prior knowledge of the subject.

2.3. Procedure and Materials

Once the theoretical part of the course was taught, students started the practical computer assignment in groups of three people. The students mainly used MySQL as a database management system, and they operated it through a console and MySQL Workbench. Secondarily, they also used MariaDB as a database management system and operated it with phpMyAdmin.

In the assignment, students mainly faced the following tasks: (1) configuration and creation of a MySQL database; (2) realization of an Extraction-Transformation-Load process from several MS Excel files; (3) optimization of queries using indexes; (4) creation of users and provision of permissions; (5) backup and recovery operations; (6) configuration and creation of a MariaDB database; (7) migration from MySQL to MariaDB database. The students performed the assignment in eight 2 h practical lessons, also working autonomously out of class. To complete the assignment, the students submitted a group report in which the procedures employed to solve the above-mentioned tasks must be explained.

The students were free to use any resource they considered to complete the practical assignment: notes and tutorials provided by the teacher, explanations of the teacher or colleagues, Googling, traditional websites (e.g., Stack Overflow, MySQL official website, etc.), and GenAI systems (specifically, ChatGPT v.3.5). The students were encouraged to use all possible resources, and in the practical sessions, the teacher exemplified the utilization of these resources, solving some problems with their use.

Once the assignment was completed and the report was submitted, the students took the individual exam in a 1 h and a half session. The examination included tasks that were similar to those previously outlined in the numbered list, specifically items 1, 2, 5, 6, and 7. To perform the individual exam, the students were free to use any resource they considered, except for messaging applications that would allow them to communicate synchronously with other people. This included the assignment report, tutorials provided by the teacher, Googling, traditional websites, and ChatGPT v.3.5.

Subsequently, upon completion of the assignment and the individual examination, the students were invited to participate in a questionnaire about the usage and utility of the employed resources. The questionnaire was delivered online through the virtual learning environment of the course. Before submitting the questionnaire, students gave their informed consent to use the collected information for research purposes.

Lastly, regarding the employed materials, it is worth noting that all students declared that they had a free ChatGPT account (i.e., version 3.5 at the time the experiment was carried out) that they could use during the course.The students committed that, if they used ChatGPT, they would use version 3.5. Otherwise, if some students used more advanced versions of ChatGPT, the principles of accessibility and equality would be violated. In addition, the teacher monitored the students' screen use during the assignment realization and the exam, and no uses of ChatGPT versions other than 3.5 were identified.

2.4. Methods and Instruments

The initial data collected in this case study are the students' grades in the practical component of the course, specifically the grade assigned to the individual examination. The grade is scored on a scale of 0 to 10, with the following categories: 0–4.9 (fail), 5–6.9 (pass), and 7–10 (outstanding). The second dataset comprises the results of a questionnaire administered to collect students' opinions about the utilized resources during the assignment and the exam realization.

The questionnaire comprised three sections. The first section included questions about age, gender, and classroom attendance. The second section included statements about the usage and utility of some resources available for the students during the assignment, as well as a question about the purpose for which they used ChatGPT (if used). The third section was like the second one, but addressed the resources employed during the completion of the individual exam. In the statements about the usage and utility of the available resources, the students should indicate a level using a Likert scale from one (nothing) to five (a lot). In the statements about the utility of these resources, the students could also select the option 'don't know/no answer', provided when they did not use a certain resource. The questionnaire items are presented together with the results.

2.5. Data Analysis

The collected data are publicly available at the following link: https://doi.org/10.21950/CHKXAH. The results of the student's grades and the questionnaire were analyzed by using two descriptive statistics: the mean (M) and the standard deviation (SD). Moreover, inferential results were computed. To do so, the Kolmogorov–Smirnov test of normality was conducted to check the normality of the data, which resulted in not being normally distributed. Therefore, non-parametric statistical methods were used.

First, the Kruskal–Wallis test was employed to compare and find possible statistically significant differences in the usage and utility of the available resources among the students according to their grades. Moreover, the eta squared coefficient was employed to study the effect size of these differences. Regarding this coefficient, it must be considered that a value between 0.01 and 0.06 means a small effect size, a value between 0.06 and 0.14 means a medium effect size, and a value greater than 0.14 means a large effect size.

Second, the Spearman correlation test was employed to correlate the student's grades with the student's responses to the questionnaire items. Regarding the Spearman correlation coefficient (Rho), a positive value means a positive correlation and a negative value means a negative correlation. Moreover, a value lower than |0.1| means there is no correlation, between |0.1| and |0.3| means a low correlation, |0.3|–|0.5| a medium correlation, |0.5|–|0.7| a high correlation, and greater than |0.7| means a very high correlation.

3. Results

3.1. Student's Grades

Figure 2 depicts the students' grades. The mean grade is 4.94 with an SD of 2.74. Of the 37 students, 16 failed the exam (grade lower than 5), 9 obtained a grade of pass (grade between 5 and 7), and 12 obtained a grade of outstanding (grade higher than 7).

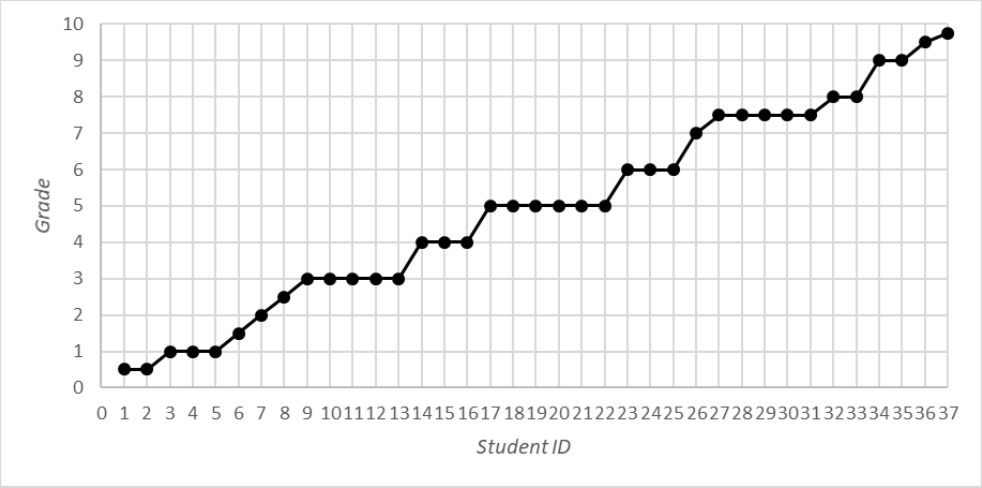

Figure 2. Student's grades.

3.2. Usage and Perceived Utility of Resources

3.2.1. During the Assignment Realization

The results obtained from the second section of the questionnaire show the usage and utility of some learning resources available to perform the assignment. The specific questions are 'To what extent have you used the following resources to perform the assignment?' (usage), and 'How useful are the following resources to perform the assignment?' (utility). Table 1 depicts these results, ordering the resources from highest to lowest usage. Moreover, the questionnaire also included a specific question about the purposes (that could be multi-selected from a closed list) for which students used ChatGPT during the realization of the assignment. Figure 3 depicts these results, ordered by the number of occurrences. Note that 9 out of 37 students (around 25%) did not use ChatGPT during the assignment realization and the remaining students (around 75%) did use it.

Table 1. Usage and utility of resources during the assignment.

	Item	Usage M (SD)	Utility M (SD)
1	Assignment materials (i.e., teacher tutorials)	4.38 (0.76)	3.92 (1.20)
2	Traditional internet resources (Google, Stack Overflow, etc.)	4.08 (0.98)	4.16 (1.01)
3	Explanations of my group colleagues	3.78 (1.18)	3.92 (1.00)
4	Individualized teacher's explanations	3.57 (1.19)	4.23 (0.94)
5	MySQL official documentation	3.51 (1.19)	3.47 (1.08)
6	General teacher's explanations	3.49 (1.30)	4.00 (0.97)
7	ChatGPT v3.5	3.03 (1.46)	3.69 (1.17)

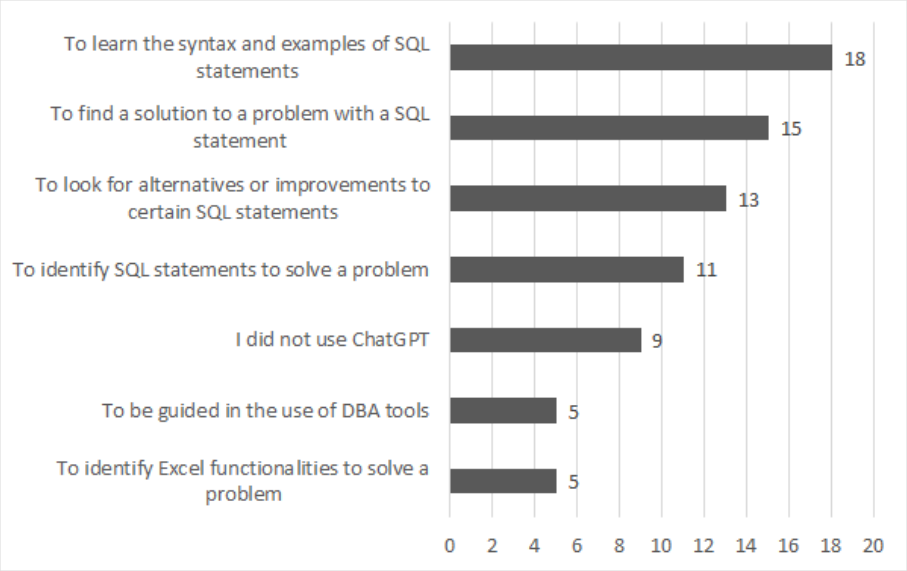

Figure 3. Usage of ChatGPT during the assignment.

3.2.2. During the Exam Realization

The results obtained from the third section of the questionnaire show the usage and utility of some learning resources available to perform the individual exam. The specific questions are as follows: 'To what extent have you used the following resources to perform the individual exam?' (usage), and 'How useful are the following resources to perform the individual exam?' (utility). Table 2 depicts the resource results ordered from highest to lowest usage. Moreover, the questionnaire also included a specific question about the purposes, for which students used ChatGPT during the realization of the individual exam. Figure 4 depicts these results, ordered by the number of occurrences. Note that 21 out of 37 students (around 55%) did not use ChatGPT during the individual exam realization and the remaining students (around 45%) did use it.

Table 2. Usage and utility of resources during the exam.

	Item	Usage M (SD)	Utility M (SD)
1	Assignment report	4.49 (0.84)	4.59 (0.76)
2	Assignment materials (i.e., teacher tutorials)	3.03 (1.36)	3.46 (1.12)
3	Traditional internet resources (Google, Stack Overflow, etc.)	2.73 (1.56)	3.53 (1.44)
4	MySQL official documentation	2.27 (1.33)	2.96 (1.33)
5	ChatGPTv3.5	2.14 (1.55)	3.00 (1.54)

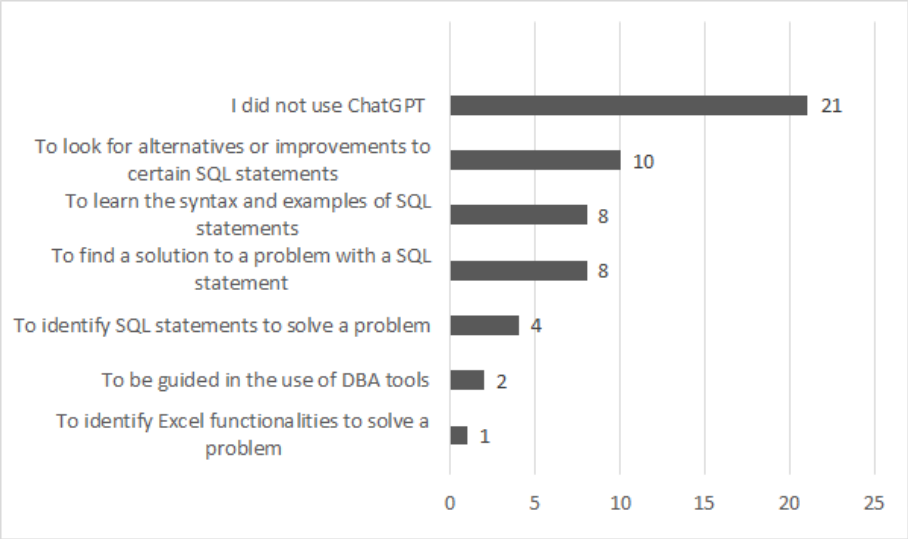

Figure 4. Usage of ChatGPT during the exam.

3.3. Usage and Perceived Utility of Resources Grouped by Student's Grades

The students could be grouped by grades according to the scale previously mentioned: fail, pass, and outstanding. This leads to three groups: Group 1 (grade = fail, N = 16), Group 2 (grade = pass, N = 9), and Group 3 (grade = outstanding, N = 12). The differences presented in the following Tables were analyzed by using the Kruskal–Wallis test, marking with a '*' symbol wherever a statistically significant difference appears.

3.3.1. During the Assignment Realization

Tables 3 and 4 depict, respectively, the usage and utility of the available resources during the assignment. For each group, the mean and the standard deviation (in parentheses) are displayed.

Table 3. Usage of resources during the assignment (grouped by grades).

	Item	Group 1	Group 2	Group 3
1	Assignment materials (i.e., teacher tutorials)	4.13 (0.70)	4.67 (0.71)	4.50 (0.80)
2	Traditional internet resources (Google, Stack Overflow, etc.)	4.25 (0.97)	4.11 (1.27)	3.83 (0.72)
3	Explanations of my group colleagues	3.56 (1.17)	4.33 (1.12)	3.67 (1.15)
4	MySQL official documentation *	3.63 (0.93)	4.22 (0.83)	2.83 (1.40)
5	General teacher's explanations *	2.88 (1.41)	4.67 (0.50)	3.42 (0.90)
6	Individualized teacher's explanations *	2.88 (1.17)	4.78 (0.44)	3.58 (0.79)
7	ChatGPT v3.5	2.63 (1.17)	3.33 (1.66)	3.33 (1.61)

Statistically significant differences are marked with the '*' symbol.

There are three differences identified as statistically significant at the 0.05 level in Table 3. In these items, the *p*-value and eta squared value are as follows: item 4: *p*-value = 0.03/eta squared value = 0.13; item 5: *p*-value < 0.01, eta squared value = 0.27; item 6: *p*-value < 0.01/ eta squared value = 0.41.

Table 4. Usage of resources during the assignment (grouped by grades.)

	Item	Group 1	Group 2	Group 3
1	Assignment materials (i.e., teacher tutorials) *	3.33 (1.35)	4.78 (0.44)	4.00 (0.95)
2	Traditional internet resources (Google, Stack Overflow, etc.)	3.94 (1.03)	4.00 (1.32)	4.58 (0.51)
3	Explanations of my group colleagues	3.63 (1.11)	4.44 (0.73)	3.91 (0.83)
4	MySQL official documentation *	3.07 (1.06)	4.22 (0.67)	3.42 (1.08)
5	General teacher's explanations *	3.60 (1.05)	4.67 (0.71)	4.08 (0.67)
6	Individualized teacher's explanations *	3.50 (0.91)	5.00 (0.00)	4.50 (0.67)
7	ChatGPT v3.5 *	3.09 (0.79)	3.63 (1.30)	4.40 (1.07)

Statistically significant differences are marked with the '*' symbol.

Five differences identified as statistically significant at the 0.05 level appear in Table 4. In these items, the p-value and eta squared value are as follows: item1: p-value = 0.02/eta squared value = 0.16; item 4: p-value = 0.03/eta squared value = 0.43; item 5: p-value = 0.02, eta squared value = 0.17; item 6: p-value < 0.01/eta squared value = 0.43; item 7: p-value = 0.01/eta squared value = 0.17.

Lastly, the results regarding the item 'I did not use ChatGPT (during the assignment)' are analyzed by groups (Figure 5).

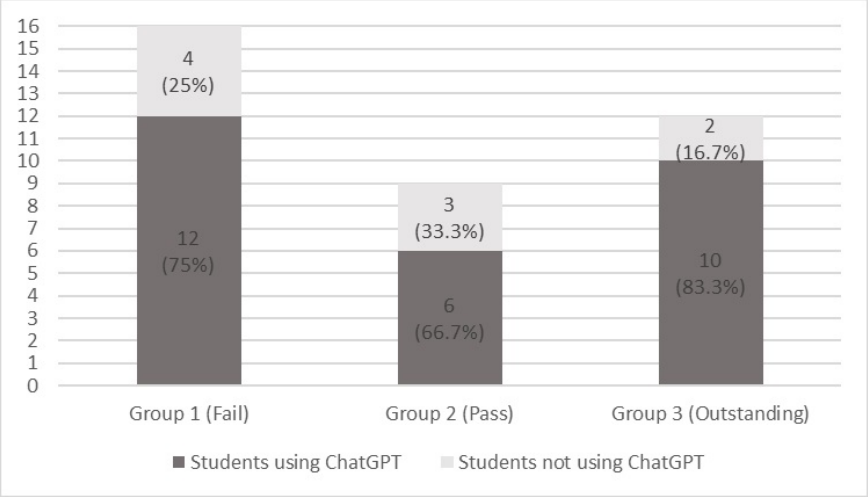

Figure 5. Usage of ChatGPT during the assignment (results grouped by grades).

3.3.2. During the Exam Realization

Tables 5 and 6 depict, respectively, the usage and utility of the available resources during the exam. For each group, the mean and the standard deviation (in parentheses) are displayed.

Table 5. Usage of resources during the exam (grouped by grades).

	Item	Group 1	Group 2	Group 3
1	Assignment report	4.38 (0.69)	5.00 (0.00)	4.25 (1.13)
2	Assignment materials (i.e., teacher tutorials)	3.43 (1.41)	2.66 (1.65)	2.75 (0.86)
3	Traditional internet resources (Google, Stack Overflow, etc.)	3.00 (1.32)	2.66 (2.00)	2.41 (1.50)
4	MySQL official documentation	2.31 (1.04)	2.88 (1.83)	1.75 (1.05)
5	ChatGPT v3.5	1.81 (1.23)	1.66 (1.41)	2.91 (1.78)

Although there appear to be some notable differences when applying the Kruskal–Wallis test, no difference is identified as statistically significant at the 0.05 level in Table 5. Nevertheless, in item 5 (the usage of ChatGPT), the resulting p-value is 0.14, and the eta squared value is 0.06.

Table 6. Utility of resources during the exam (grouped by grades).

	Item	Group 1	Group 2	Group 3
1	Assignment report	4.56 (0.60)	5.00 (0.00)	4.33 (1.07)
2	Assignment materials (i.e., teacher tutorials)	3.75 (0.96)	3.42 (1.51)	3.08 (0.99)
3	Traditional internet resources (Google, Stack Overflow, etc.)	3.60 (1.20)	3.25 (1.90)	3.66 (1.41)
4	MySQL official documentation	2.88 (1.21)	3.16 (1.72)	3.00 (1.22)
5	ChatGPT v3.5 *	2.37 (0.99)	2.20 (1.78)	3.90 (1.37)

Statistically significant differences are marked with the '*' symbol.

In Table 6, there is a difference identified as statistically significant at the 0.05 level in the item about the usage of ChatGPT, where the *p*-value is 0.04 and the eta squared value is 0.13. Figure 6 shows the results regarding the item 'I did not use ChatGPT (during the exam)' analyzed by groups.

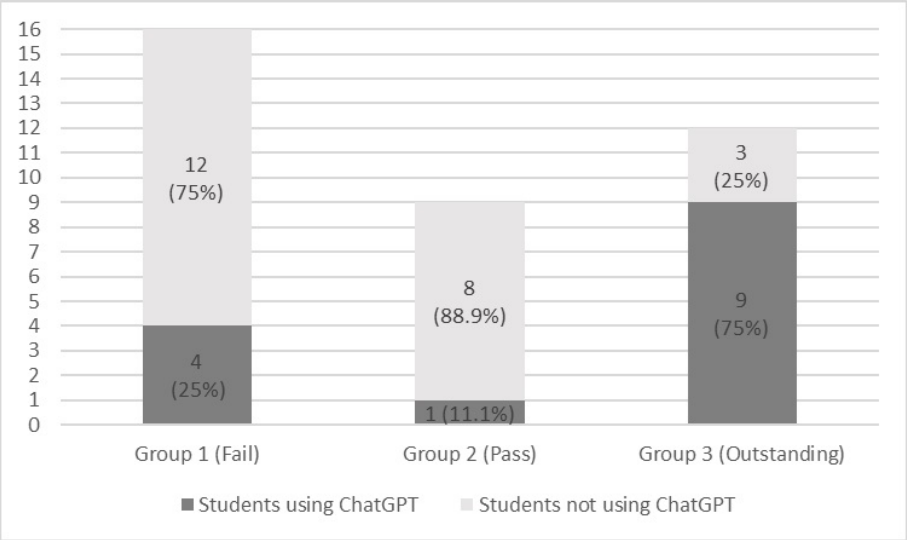

Figure 6. Usage of ChatGPT during the exam (results grouped by grades).

3.4. Relation Between the Student's Grades and the Usage and Utility of Resources

Correlations using the Spearman technique were computed in order to know how the student's grades were related with the usage and perceived utility of the available resources during the assignment and the exam realization, as well as with the usage of ChatGPT. Table 7 depicts the assignment realization results, whereas Table 8 depicts the individual exam realization results. In both cases, the correlations are represented using the Spearman value (Rho) and the *p*-value. The correlations statistically significant at the 0.05 level are marked with the '*' symbol.

Table 7. Correlation between the student's grade and the usage and utility of resources during the assignment realization.

	Item	Usage	Utility
1	Assignment materials (i.e., teacher tutorials)	0.31 (0.06)	0.26 (0.12)
2	Traditional internet resources (Google, Stack Overflow, etc.)	−0.26 (0.11)	0.23 (0.1)
3	Explanations of my group colleagues	−0.06 (0.71)	0.06 (0.71)
4	MySQL official documentation	−0.14 (0.41)	0.23 (0.17)
5	General teacher's explanations	0.23 (0.17)	0.29 (0.08)
6	Individualized teacher's explanations	0.32 (0.05) *	0.50 (<0.01) *
7	ChatGPT v3.5	0.18 (0.28)	0.46 (0.01) *

Table 8. Correlation between the student's grade and the usage and utility of resources during the exam realization.

	Item	Usage	Utility
1	Assignment report	0.11 (0.51)	≈0 (0.97)
2	Assignment materials (i.e., teacher tutorials)	−0.33 (0.04) *	−0.27 (0.10)
3	Traditional internet resources (Google, Stack Overflow, etc.)	−0.22 (0.19)	0.01 (0.94)
4	MySQL official documentation	−0.20 (0.22)	0.12 (0.58)
5	ChatGPT v3.5	0.22 (0.18)	0.34 (0.10)

Moreover, the correlations between the student's grade and the item 'I did not use ChatGPT (during the assignment)' were computed, with Rho = −0.13; *p*-value = 0.44, as well as between the student's grade and the item 'I did not use ChatGPT (during the exam)', with Rho = −0.42; *p*-value = 0.01.

4. Discussion

4.1. RQ1: Is the Use of ChatGPT Perceived as a Valuable Tool Among Computer Science Students to Learn Database Administration?

In light of the presented results, it can be said that GenAI tool use is not so much extended among our CS students to learn DBA if we compare it with other learning resources such as personal reports, ad hoc tutorials made by the teacher, explanations of teachers and colleagues, or traditional websites (e.g., Google, Stack Overflow, etc.). Indeed, GenAI was the least-used resource for both the assignment realization (see Table 1) and the individual exam (see Table 3). The resources most used by the students to perform the practical assignment and the exam were, respectively, the assignment materials (i.e., tutorials provided by the teacher) and the assignment group report (i.e., student's resolution of the proposed tasks).

However, despite this, the usage of ChatGPT was moderately rated. Specifically, it was rated with a 3.03 (out of 5) and a 2.14 during the assignment and exam realization, respectively. Moreover, 75% of the students used ChatGPT at some time to perform the practical assignment and 45% used it to perform the individual exam. Among the uses of ChatGPT to perform DBA tasks, the students mostly used ChatGPT to learn about some SQL statements, to solve problems with an SQL statement, and to look for alternatives or improvements to certain SQL statements (see Figures 3 and 4). To be more specific, ChatGPT proved to be quite useful for students who wanted to learn details about SQL statements for creating users or granting permissions. Moreover, when the statements for updating permissions failed (for example, because the user's role had not been activated), ChatGPT provided them with alternatives to solve this error and activate the user's role in multiple ways. Even so, ChatGPT was not particularly useful in the processes of Extract-Transform-Load (ETL) or in the configuration of Database Management Systems. Although ChatGPT could initially provide some information to carry out certain tasks when problems began to arise, ChatGPT struggled to find the solution, which ultimately came from the teacher, a classmate, or other traditional sources like a highly upvoted thread on Stack Overflow.

As the TAM model [23,24] indicates, the use of a technology is influenced by its perceived ease of use and its perceived usefulness (which will be discussed in the next question). The simplicity of the utilization of ChatGPT is contingent upon the possession of specific prompting abilities. These were trained with the professor's support through the practice sessions, during which several examples were provided for the resolution of practical DBA issues with the use of ChatGPT. Moreover, the ease of use also depends on the user's knowledge of the topic he/she wishes to explore. In this last regard, the following observation is interesting.

The use of ChatGPT was not uniform among the students and it is relevant to observe the usage of this tool among students categorized on the basis of their grades. During the realization of the practical assignment (see Table 5), a certain difference can be observed between the use made of ChatGPT by students who succeeded in the exam (3.33 out of 5)

and those who did not (2.63). Moreover, the proportion of students using ChatGPT was somewhat higher in the case of students who obtained a grade of outstanding (see Figure 5). In particular, 83.3% of the students in this group used ChatGPT, versus 75% and 66.7% of the students who used it in the fail and pass groups.These differences are even greater if we examine the use of ChatGPT during the exam realization (see Table 7). The difference continues to be in favor of students who obtained a grade of outstanding (2.91 out of 5) versus those who obtained a grade of pass (1.81) or fail (1.66). It is remarkable that in this case, the difference had a medium effect size (eta squared value = 0.06). Moreover, by examining the proportion of students using ChatGPT among the different groups of students (see Figure 6), it can be observed that 75% of the students in the outstanding group used ChatGPT, whereas the students of the fail and pass group used it much less (25% and 11.1%, respectively). The data indicate that students who received lower grades did not attain the requisite proficiency in ChatGPT for DBA problem-solving during the assignment. This may be attributed to a lack of DBA knowledge or a deficiency in prompting skills, or a combination of both. Consequently, the majority of students opted not to utilize this tool during the examination.

In light of the aforementioned evidence, it can be reasonably inferred that, while ChatGPT is not currently being utilized by our computer science students to the same extent as more traditional learning resources for learning database administration, it is nevertheless being employed to a moderate extent. This conclusion is fully consistent with the work presented by [18], where the usage of ChatGPT is still not so widespread in this student profile. Nevertheless, the usage of ChatGPT is not uniform and is especially pronounced among students who obtain higher grades, which may indicate that (a) the proper use of ChatGPT helps students to obtain better grades; (b) high-performing students know how to make better use of ChatGPT; (c) a combination of both, which sounds more reasonable.

4.2. RQ2: Which Computer Science Student Profiles Are More Likely to be Successful Users of ChatGPT to Learn Database Administration?

With regard to the efficacy of ChatGPT for acquiring knowledge about DBA, once again, the students did not consider it to be as beneficial as the other learning resources. In fact, during the assignment realization (see Table 1), this tool was perceived as less useful than the explanations of the teacher or colleagues, the tutorials provided by the teacher or traditional internet resources, while during the exam realization (see Table 3), ChatGPT was perceived as less useful than the assignment report or traditional internet resources.

Nevertheless, setting aside the comparison of ChatGPT with other learning resources, the degree of usefulness of this tool is becoming moderately high. Indeed, the students rated the degree of usefulness of ChatGPT for the completion of the assignment and the examination, respectively, at 3.69 (out of 5) and 3.00. As commented before, the students primarily utilized ChatGPT to enhance their understanding of SQL syntax and examples, to identify solutions to SQL statement-related issues, and to explore alternative or enhanced approaches to specific SQL statements (see Figures 3 and 4).

Once more, the perceived usefulness of ChatGPT was not consistent among our student population. It is intriguing to examine the perceived utility of this tool among students with different grades. Regarding the assignment realization (see Table 6), a significant statistical difference with a large size effect in the usefulness of ChatGPT was found. This difference is in favor of the students who obtained a grade of outstanding (rating 4.40), as opposed to those students who obtained a grade of pass or fail, who rated the usefulness of ChatGPT much lower (3.63 and 3.09, respectively). In the same vein, regarding the exam realization (see Table 8), a significant statistical difference with a medium-to-large size effect was found. In this case, the students of the outstanding group rated ChatGPT utility with a 3.90, whereas the students of the pass and fail groups rated it with a 2.20 and 2.37, respectively. Furthermore, it is striking to note that for the students who obtained a grade of outstanding, ChatGPT was slightly more useful than other traditional resources.

Meanwhile, the groups of students who obtained lower grades rated ChatGPT as the least useful resource, especially for taking the exam. This finding is consistent from the perspective of the TAM model [23,24], which posits that ease of use is a key determinant of perceived usefulness. This is indeed a factor that has been previously discussed in the context of RQ1 and, in the case of ChatGPT, is influenced by both the user's prompting skills and knowledge of the topic to be explored.

Therefore, two main conclusions can be drawn from this discussion. First, in general terms, ChatGPT is perceived by CS students as a moderately useful resource for learning about DBA, although not as useful as other traditional learning resources. This reinforces the results of the recent studies of [17,19], indicating that CS students require additional assistance from educators rather than relying exclusively on ChatGPT. It is also correlated with the [18] study in which the students declared that ChatGPT usage could not be the only source to rely on. Nevertheless, our study shows an increment of respect for these related works of GenAI usage, as is expected due to the increment of its knowledge and its widespread overall use. Secondly, students who achieve higher grades have a markedly divergent perception of ChatGPT's utility compared to students with lower scores. They perceive ChatGPT as a highly useful tool, even more so than other conventional resources. This may indicate that high-achieving students are more adept at leveraging ChatGPT's capabilities (due to their DBA knowledge, prompting skills, or a combination of both), leading to a more favorable assessment of its utility. Conversely, lower-achieving students may not possess the same proficiency, resulting in a less positive perception. This aligns with the potential self-reinforcement of equity issues, akin to the Mathew Effect: students with lower initial literacy tend to gain less from the use of new tools, widening the gaps between those grouped by skills. The ChatGPT usage can also be related to an increment of student motivation, a result that appeared in [17] and that could be a feedback loop: higher use, higher motivation, deeper study, higher marks.

4.3. RQ3: Might the Utilization of ChatGPT Impact the Academic Performance of Computer Science Students Who Are Learning Database Administration?

Analyzing Tables 5–8, it can be said that there is a relation between the usage and perceived utility of ChatGPT and the student's academic performance. To further explore this relation, the results correlating the students' grades and the usage and perceived utility of ChatGPT will be taken into consideration.

First, the assignment realization results (see Table 7) show that there is a positive correlation between the student's grade and the usage of the ChatGPT (Rho = 0.18). Similarly, it is also interesting to note how the item related to the non-use of ChatGPT correlates negatively with the student's grade (Rho = −0.13). Nevertheless, the learner draws from many sources of knowledge, and their academic performance is impacted by all of them. So, it is important to highlight other positive correlations found: individualized teacher explanations (Rho = 0.32), tutorials provided by the teacher (Rho = 0.31), and general teacher's explanations (Rho = 0.23). Regarding the correlations of the student's grade with the perceived utility of the resources, the high values obtained for individualized teacher explanations are remarkable (Rho = 0.50), as well as for ChatGPT (Rho = 0.46).The aforementioned evidence indicates the value of Universal Design for Learning and the provision of multiple learning paths, in addition to literacy development. In fact, the integration of ChatGPT during the assignment realization process, coupled with the utilization of teacher explanations and materials, has been demonstrated to be an effective approach, resulting in enhanced performance.

Second, the exam realization results (see Table 8) show that there is a positive correlation between the student's grade and the use of ChatGPT during the exam (Rho = 0.22). There is also a positive correlation between the student's grade and the perceived usefulness of this tool (Rho = 0.34). In the same vein, it is also interesting to note the negative correlation between the student's grade and the non-use of ChatGPT (Rho = −0.42), which is statistically significant at the 0.01 level. Examining the results related to other learning

resources, another positive correlation between the student's grade and the usage of the assignment report can be observed, which contains the student's resolution of the tasks proposed in the assignment. In addition, negative correlations can be observed between the student's grade and the rest of the available resources: teacher's tutorials, traditional websites, and the MySQL official website. These resources were highly used and perceived as helpful during the assignment realization (see Table 1), but the low use and perceived usefulness during the exam (see Table 3), in conjunction with these negative correlations, suggest that the individual exam, when time was limited, was not suitable for consulting these sources. However, it seems that the assignment report combined with the proper usage of ChatGPT was highly effective. These results, together with the aforementioned correlations between the ChatGPT use during the assignment and the student's grade, suggest that the students who used ChatGPT properly and sufficiently during the assignment realized and acquired the knowledge and skills to use ChatGPT as an aid to solving DBA problems had a powerful ally when they took the exam.

Therefore, it can be concluded that ChatGPT is a helpful tool to assist in the resolution of DBA problems and seems to positively impact student performance. This is partially consistent with the work of [21], in which improvements in academic performance were connected to the use of GenAI. However, that work showed that the lowest-rated students improved their performance with the use of a chatbot, contrary to our conclusions. It could be a consequence of using a specific chatbot deployed for the subject, while ChatGPT is a general GenAI that seems to be more useful for higher-skilled students. The chicken-and-egg causality dilemma persists in this context. It remains uncertain whether high-performing students excel in a subject because they utilize ChatGPT, or if their proficiency with ChatGPT is a consequence of their stronger subject matter knowledge. Interestingly, Ref. [21] declared that high-performing students suggested the implementation of more complex items for their chatbot, which points toward the second direction. Here, we can see how a new digital gap could be rising between students with higher skills and knowledge who can improve their results, compared with the ones with lower degrees of fundamentals, who may not take advantage of all the ChatGPT possibilities.

Consequently, in order to reduce this gap and allow all students to obtain the most from GenAI, and in line with [17], it is imperative that educators promote advanced critical thinking skills. To this end, it is crucial that teachers are equipped with the knowledge and skills to effectively teach their students how to prompt at a higher level. This is a vital competency for professionals in various fields. The course will equip students with two distinct tools: an enhanced capacity for critical analysis and a proficiency in information retrieval through the utilization of GenAI, a technology that will become a core competency in their professional pursuits. Furthermore, our empirical evidence suggests that an elevated level of literacy correlates with a more effective utilization of digital tools, extending beyond the scope of GenAI. Consequently, it is imperative to invest additional resources in nurturing the growth of students with lesser developed skills, bridging the gap between them and their more proficient counterparts.

5. Conclusions

This paper has presented an empirical study with CS students about the usage of ChatGPT in learning DBA. The main findings are as follows:

1. ChatGPT was moderately used, but not as much as other traditional learning resources. Likewise, ChatGPT was perceived as moderately useful, although not as much as other resources.
2. Students who obtained higher grades used ChatGPT the most and found it to be a very useful resource, even more than some traditional learning resources.
3. Positive correlations were found between the student's grade and the use and perceived usefulness of ChatGPT. Other learning resources that correlated positively with student performance were teacher's explanations and tutorials, and student's reports and notes.

The aforementioned findings permit the conclusion that ChatGPT is an efficacious educational instrument for the resolution of DBA issues, particularly in the context of high-performing students. To do so, students should be trained on the usage of this tool and practice to master it. Nevertheless, ChatGPT should be combined with other traditional resources to learn DBA, the teacher's resources and explanations being especially important, as well as the reports or notes made by the student during the practical part of the course. This is aligned with some recent studies, where the necessity of teacher's assistance is recognized by the students. At the same time, other recent educational research works in this area also show that the best-ranked students are also the ones who use ChatGPT more in their learning. These precedents are reinforced by our work. We add that the Guided Practice strategy, which entails prompting and guiding the whole class through step-by-step practice,can be effective in leveraging the student population, increasing their literacy, and promoting engineering skills at the same time. We deem that these conclusions, although strongly connected to CS education, are fully transferable to any engineering or science discipline in which the practical mastery of technologies and problem solving play a key role.

It is important to note that, despite the positive outcomes, this contribution is not without limitations. Firstly, since no pre-test was conducted, the assessment of learning gains during the experience may be misleading. We considered that it was not so necessary to conduct a pre-test since the students had no prior knowledge of the subject (note that the repeating students were excluded from the sample and that addressed topics were totally new to participating students). In any case, future studies will follow a pre-post-assessment strategy. This, coupled with the conduction of a randomized controlled trial where ChatGPT usage is isolated, will allow us to ascertain cause-and-effect relationships, such as that the use of ChatGPT will always result in high academic performance or that students who perform better do so exclusively as a result of using ChatGPT. Secondly, the sample size of 37 students is insufficient for generalizing the conclusions. Undoubtedly, additional case studies, ideally with a larger sample size, should be conducted to consolidate the conclusions. Furthermore, the limited sample size precludes an analysis from a gender perspective, which could also be a valuable avenue for further investigation. Finally, in future studies, it would be interesting to collect information about the different learning styles, prior educational backgrounds, and previous ChatGPT experiences of the participating students, and to correlate this information with the usage and perceived utility of the available learning resources.

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Abbreviations

The following abbreviations are used in this manuscript:

GenAI	Generative Artificial Intelligence
UNESCO	United Nations Educational, Scientific, and Cultural Organization
LLM	Large Language Models

DBA	Database Administration
SQL	Structured Query Language
AI	Artificial Intelligence
TAM	Technology Acceptance Model
RQ	Research Question N
ECTS	European Credit Transfer System

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