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Pedagogy with generative artificial intelligence: Opportunities and challenges in education

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Abstract

Students using ChatGPT demonstrated significantly superior performance on AI-assisted assignments ($p < 0.001$), reporting benefits including time efficiency, personalized learning experiences, and enhanced conceptual understanding. However, these advantages came with notable trade-offs: the AI group scored lower on proctored examinations ($p < 0.01$), suggesting potential overreliance that may hinder independent learning capabilities. Student perceptions revealed this tension, with 71% acknowledging AI dependence for task completion while 58% expressed concerns about compromised learning depth. The research identifies critical risks accompanying AI integration: concerns about content accuracy, plagiarism vulnerabilities, ethical dilemmas, and the potential erosion of deep learning. Traditional assessment methods, particularly take-home assignments, proved inadequate in AI-enabled environments, highlighting the need for fundamental pedagogical restructuring. The authors advocate for comprehensive educational reform encompassing redesigned assessments that prioritize genuine understanding over AI-generated responses, institutional policy frameworks governing ethical AI use, and systematic AI literacy development among students and educators. The study emphasizes that generative AI's transformative potential, including personalized tutoring, immediate feedback, and content generation efficiency can only be realized through deliberate pedagogical innovation. The research calls for longitudinal studies examining sustained learning outcomes, discipline-specific AI applications, and development of evidence-based guidelines balancing educational enhancement with academic integrity preservation. Ultimately, the study positions generative AI as a "double-edged sword" requiring proactive adaptation from educational stakeholders to ensure it serves as a pedagogical ally rather than undermining educational foundations.

Keywords: Pedagogy, Education, Generative artificial intelligence, Ethics, ChatGPT, Acceptance.

1. Introduction

The advent of the strong generative artificial intelligence (AI) models has led to a new stage in education where the fundamentals of education begin to be put into question at both the instructional and the learning end. Education is essentially an issue related to the creation of knowledge and skills; so all significant changes in technology such as calculators or computers have initially caused enthusiasm and anxiety among the educators [1-3]. There have been unprecedented achievements in the generation of human-style text, problem solving and even images or code generation with general AI systems such as OpenAI GPT-5 (popularly accessed via ChatGPT). These tools could have an extensive influence on the improvement of education by offering education to the individual level, customizing the content, practice quizzes, and explanations to students individually, function as virtual tutors, and offer instant feedback. Such possibilities are in line with traditional pedagogical aims: to be able to adjust to the needs of each learner, as well as to assist learners in a timely manner [2,4]. There is an initial indication that the idea of large language model (LLM) technology may be able to truly achieve an unprecedented

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amount of adaptive learning, at scale, such as AI-assisted tutors providing customized instructions, or teachers through automating tedious business operations like designing exams or providing feedback. Ideally, generative AI could relieve human trainers of certain menial duties and enable them to engage more in more complicated facilitation of learning. Moreover, generative AI can generate interactive opportunities and natural language descriptions which may involve students in constructivist learning experiences in which they build knowledge by having a dialogue and exploring. An example is the case whereby a learner with a problem in physics might engage an AI tutor to explain the concept or use an analogy to them or an English learner may get real time reviews on writing style and grammar. The capabilities suggest a change in the methodologies of pedagogy - making the learning processes more student-oriented and differentiated as well as responsive.

There exists a multiplicity of pedagogical opportunities of generative AI. To start with, AI-based tutors and discussion partners can offer one-on-one scaffolding and Socratic questions on a large scale, which human educators with large classes cannot constantly provide to students [5-8]. This elective study has illuminated that the generative AI has the potential to assume the role of virtual language instructors, generate practice tasks, and adapt to the level of a learner, enhancing interest and, as a result, possibly, promoting better learning outcomes due to the personalization aspect [6,9]. A tool such as ChatGPT can be used in quite different fields such as language learning, where one can use conversational practice simulated by the tool or get instant translation and grammar checking based on the pace of the language learner. With topics that contain a lot of content, generative AI can be used to overviews of complicated information or draw up examples that clarify complex concepts; and this aids in helping the student in mastering a complex concept. Furthermore, the learning tools can automatically create educational resources: problems to practice, questions to be put in the quiz, reading summaries, and even lesson plans. Educators have an opportunity to use AI to write lesson plans or create various variants of the explanations that will suit the particular levels of proficiency. It may also help in the assessment design whereby a pool of questions is created or in real time, the questions are modified to fit the performance level of a student. All this usage is an indication that with proper implementation, the generative AI can not only enhance learning activities but also streamline and transform learning systems.

But there are also deep issues of educational practice and policy associated with the emergence of generative AI. One of the primary issues is school honesty. What prevents students to cheat on their assignments with the help of an AI when this type of AI can compose the passable essay or solve a set of problems? As a matter of fact, it is becoming clear that the abilities of generative AI have already made students capable of completing assessments within a short time, and providing quality results that went undetected. This has led to the alarm on the issue of plagiarism and cheating [10-12]. The educational process is even given by one of the notable critics as a form of high-tech plagiarism... a means of avoiding learning what ChatGPT is, which essentially compromises the educational process. Teachers are concerned that simple access to on-demand famous services will destroy not only the learning process but also the motivation to learn and gain professional skills, so they will learn to overuse artificial intelligence-generated responses. The authenticity of the degrees and certifications is at stake in case the assessments cease reflect a student personal knowledge and his/her hard work. Parallel to it, the issue is complicated by the fact that AI-written content is hard to catch. It is documented that AI-detection technologies are currently mostly inaccurate and commonly ability to produce false positives and false negatives, detecting as AI-written harmless student texts and AI-written harmful texts. This is what makes the incorporation of honesty in coursework quite difficult. Recent systematic review found that, despite the fact that GenAI is dramatic to increase the learning process through personalized activities, it was also a threat to the principles of academic honesty. The instructors are in a game of technology versus technology, as they seek to come up with new assessment types or resort to proctoring and lockdown browsers in case of unauthorized aid provided by AI.

Other than cheating, there is also the problem of learning quality which is not so explicit but is equally important. Students who delegate thinking to AI might avoid the processes of thinking that result in deep learning. The initial studies indicate that the negative impact of extensive use of ChatGPT may actually be quite harmful: the participants of one study were more likely to show an increase in procrastination and even a decrease in their memory and test scores. The convenience of the tool, in

particular, in situations when students are pressed by time or heavy workload, will tempt learners to rely on AI as a quick solution instead of a tool to supplement their personal thinking process. To put it another way around, it is possible that generative AI can facilitate the process of surface learning at the cost of deep learning. This can be likened to the introduction of the calculators although they made doing the calculations faster, the educators had to make certain that the students were taught the fundamentals of mathematics. Even higher is the stakes with generative AI since the tool can generate full solutions or essays, and it is possible that a student can do an assignment with little interaction with the skills underlying it, analyzing, problem-solving, or writing. The threat is the creation of students who can be effective at triggering AI but cannot think critically in the absence of AI. Consequently, there has been an outcry by some scholars regarding a perceived negative impact on students in terms of their cognitive and writing skills in case such tools are abused. There are additional reports that AI models have passed professional exams (medical, legal, business) on practice attempts which encourage the apprehension that students may use the technology to game high-stakes examinations. Reacting, several academic organizations and periodicals initially responded with an outright ban or declaration against the use of artificial intelligence in academic work, its perceived threat to the traditional concept of education.

The other issue is that of ethical and privacy. Generative AI tools can be data-demanding and in general, they can handle personal information or student-generated work. It leads to the question of general data safety and security - i.e. when students leave their class assignments or personal requests to a third-party AI application, who then owns the information and what could it be utilized? AI tools have been accidentally used to spill sensitive information or intentionally misinformed using them. Misinformation and deception were found to be the greatest perceived risks of using such tools in the interviews with students [7,13-16]. In case of a generative AI making a misguiding-sounding yet erroneous explanation, the students may be deceived - particularly in the cases when they have not yet acquired skills to critically assess the outputs of AI. It is important but non-trivial to make sure that the content offered by AI is trustworthy and real because even the most advanced models occasionally generate fake so-called facts or reasoning (the so-called AI hallucination). The above study showed that students appreciated the communicative and creative positive effects of AI but were wary of the outputs produced by AI. Similarly, matters of authenticity (having access to when and how AI is utilized) and inheriting bias in artificial information are also a concern - AI models trained on vast internet data have the potential to recreate or increase biases, which could influence the level of fairness of the contents or recommendations offered by AI. There is also an equity aspect: not every student is able to access the latest AI tools, and those who could achieve it may have an unequal advantage in the coursework unless the policies are made to level the playing field.

The introduction of generative AI presupposes new skills and sets of rules within the educational system. Most educators and professors are not ready to confront this technology in their learning places. In a qualitative study on teachers, they revealed three large challenges associated with successful implementation of GenAI, which are: (1) readiness of schools and its infrastructure to take advantage of AI tools, (2) individual teacher capabilities and awareness of AI activities and ethics, and (3) awareness of AI literacy and ethics by students [2,17-19]. This is to say that in order to make good use of AI, institutions should invest in professional development and capacity building of the instructors, refresh the technology infrastructure (e.g. to provide secure entry to AI platforms), and educate the students of responsible AI use. Without such, the use of AI in teaching can end up failing or being misused. It is true that it has been found that both learners and teachers are in need of what has been referred to as AI literacy with respect to knowing more about how AI operates, its limitations, and critical use of AI outputs. It involves such skills as creating effective prompts, comparing the AI reaction with trusted sources, and making AI an assistant, not a support. Global debates and consultations also started insisting that AI literacy be included in the curriculum on different levels to ensure future professionals are ready to work in an AI-flooded work environment. Simultaneously, institutional regulations are following behind: universities are developing amendments to honor codes, usage policies or disclosure policies regarding AI. A few have shifted to less stringent bans to more nuanced policies that still allow AI help provided there are certain conditions (e.g. they should be cited information on AI assistance or only specific tasks should be performed). Nonetheless, the development of policies remains immature and is highly diverse, which is the manifestation of a conflict between the

adoption of innovation and maintenance of academic standards. These issues continued to be the fort of commentaries and editorials in the scholarly literature, though it was reported that there were gaps in the literature with empirical research giving data-driven points of view. It has been proposed that researchers should conduct further research to identify the actual impact of generative AI on the behavior of students, their outcomes and their teaching methods applied in the real classroom setting.

In short, existing research demonstrates that generative AI technology has huge potential to augment pedagogy (personalized tutoring, enhanced student/learner engagement, automated learning) and great perils (most so academic integrity, assessment validity, depth of learning and ethical applications). Nevertheless, we still do not know much in that area. A lot of existing publications have been hypothetical or theoretical, without empirical support of how the use of generative AI actually transpire on classrooms and the effects it may have on the outcome of learning. The most important questions are under study: Do AI access enhance or worsen the student learning and under what circumstances? What are the attitudes that students and teachers have toward the use of AI - helpful tutor, a digital skill that needs, or an immoral shortcut? How could it be implemented in a way that benefits will be maximized and the disadvantages reduced? Current systematic reviews have cited the necessity to conduct research on feasible pedagogic practices, redesigning assessment, and policy frameworks to incorporate AI in education without being irresponsible. Besides, although some researches conducted have either investigated student side or teacher perspectives, few studies have presented the combination of performance and perception data in providing a complete picture of AI in the academic setting. The proposed research study will fill these gaps by offering both empirical and qualitative data, including a controlled study of the use of generative AI in an educational institution, as well as the qualitative data on the experiences of users.

This paper will provide an original research study that will analyze the practice of using generative AI in pedagogy. By quantifying the impacts that the importation of AI has on the student learning outcomes and by documenting the perceptions of stakeholders (students, as well as informally (instructor observations), we explore both opportunities and challenges. We have three goals: (1) Measure learning results - Does a generative AI-based learning tool (ChatGPT) as a study aid enhance the results of the students in their coursework and exams, or does it potentially lead to an impediment in the learning process, as some fear? We contrast AI-enhanced learning condition and traditional learning condition. (2) Find out the advantages and issues, it is necessary to define what students see as the primary benefits of the AI use in their learning process, and what are the issues or challenges of using AI (e.g., the accuracy of AI, development of dependency, ethical concerns). (3) Advise pedagogical practices and policies -We will provide our recommendations, grounded on our findings, to educators and institutions. We aim to add a deeper insight into the ways in which the generative AI can be utilized in pedagogy and what practical measures we can implement (e.g. how to construct assignments in the era of AI) and what areas we need to be cautious of or support by other means (e.g. how to make students think critically and understand AI). This work will finally contribute to the new body of empirical data on AI in education and will be useful in guiding the stakeholders navigate this multipolar, shift but demanding landscape.

2. Methodology

In order to explore the effects of generative AI on instructional learning, we developed a quasi-experimental design of a real course. The experiment was carried out at a medium-sized university in a course of undergraduate level where major parts of the course included problem-solving and writing. Students took part, and the demographic was reflective of the student population in the department. In the beginning of the semester, the participants were randomly divided into two groups having the same amount of students:

Generative AI group (Group A): These students were placed in generative AI tool (ChatGPT provided by OpenAI), and instructed to make use of it as a learning resource during the course. We clearly taught them regarding things they could use the AI to do: they were allowed to ask the AI questions about concepts covered in the course, generate hints or explanations to answered homework questions, and

receive feedback on potential drafts of written assignments. Nevertheless, they were warned that the answers provided by the AI may not necessarily be factual and they need to check out facts. Policies on academic integrity were clarified - e.g. students were permitted to brainstorm and draft using AI, but the final work must be their own clear, and if they directly copied the output of the AI, one had to proofread it and edit it. To make it easier, a personal account was assigned to every student in Group A based on the ChatGPT (GPT-5 model) and a few minutes of training on the process of creating effective prompts. The use of AI has not been graded in itself, but as a resource. Notably, in the final examination (below), no assisted computing or other aids were allowed, and this was to provide a certain degree of individual studying among students.

Control group (Group B): These students were efficient learners who used the standard way of learning without using ChatGPT or some other AI-powered tool. They were advised to use course material (text books, lecture notes) and personal efforts on assignments. The common resources they could use such as the university writing center and talk to fellow students but during the study, any use of AI tools in coursework would be expressly forbidden in this group. They were debriefed after the study and allowed to use the same AI tools to ensure there was fairness in subsequent learning. Group B is therefore used as a control group in comparison to Group A.

The two sets also had the same lectures and lab sessions taught by the same instructor and had the same content. Also, the assignment prompts and exams were the same in groups (with one exception of AI usage allowance). This has adjusted the variation of instructions, making available generative AI the leading independent variable. The pre-existing differences were eliminated by random assignment, in fact, the analysis of a diagnostic pre-test (see below) showed that there was no significant difference in prior knowledge between Group A and B (mean pre-test scores 50.7 vs 51.9 out of 100, $t(118) = -0.62$, $p = 0.54$).

2.2 Instructional Procedure and Materials.

Integration of Coursework and AI

The course consisted of weeks and had weekly homework tasks, a project in the middle, and a final examination. Homeworks had a combination of sets of quantitative problems (e.g., analysis of datasets and interpretation of the results) and short-answer questions (describing concepts, writing pieces of code, etc.). In completing these assignments, group A students were able to use ChatGPT. As an illustration, a student who is in the Group A and is focused on a data analysis task may request the AI to interpret a regression output or propose approaches to visualizing a specific set of data. Regarding a short-answer question, one of the Group A members may write an answer and then ask ChatGPT to review this answer or verify its readability. In comparison, Group B students addressed these tasks without the help of AI depending on course notes and individual arguments. The middle term project was an essay on the social effects of AI, in which Group A could consult ChatGPT and list ideas or even create a first draft, but would have to rewrite and make it unique. Group B prepared the essay without AI (however, they might search articles or references by the even traditional way). All day long, however, the instructors stressed to Group A that the AI is a support, not an oracle tool and urged them to verify information given by AI cross-handedly. The quality of assignments was checked and any suspicious similarities or AI excessive usage signs were being detected by the instructors (there were no similarities detected in Group A, other than the anticipated AI-based improvements, e.g., improved structure and grammar; respectively, Group B showed two plagiarism instances not linked to AI usage).

Final Exam

The last test was an in-class, closed-book, no internet and no AI access, 3 hours long, assessment, which was the same test in both groups. This test was a core-level test and assessment of problem-solving skills acquired throughout the course. Withdrawing access to AI throughout the exam will be a way of determining the levels of internalization of the material among students. The test was made of multiple choice questions, brief answers in the forms of explanations, and several analytical problems like the home homework ones (solvable with knowledge and by hand). Proctors made sure that none of the

students used any digital equipment. The exam was therefore an end test of learning, which could be used to make comparisons against the learning of Group A and B regarding the completion of one semester on varied study modalities.

2.3 Data Collection

Several types of data were collected by us to be analyzed:

Pre-test

At the beginning of the course, a pre-test (20 multiple-choice questions, during the first week) was provided to all the students evaluating the prerequisite knowledge and the level of understanding in essential concepts (e.g., the basic knowledge of statistics and program languages). This has observed was used to test the equivalence between groups as well as serve as a covariate in some analyses.

Assignment and Exam Scores

Assignment marks were recorded in every student on a weekly assignment, project at the mid term and final test. In the case of aggregated analysis, we calculated the average mark on assignment activities per semester (percentage scale) of each student and final exam mark (percentage) as the outcome of interest. The assignment average compares the performance of the students with the use of AI (and no assistance since the final exam is individual against both groups). The instructor and a teaching assistant graded all assessments, but we were not informed which group the students were in (assignments were submitted using the same platform, and we did not write on the submissions whether the AI was utilized). We could have performed this blinding since we told students of Group A not to specifically indicate that they were using ChatHub results when they decided on an answer; instead, they needed to incorporate any AI-generated text into their own text. The same rubrics were therefore used to grade all which made grading unbiased. We also self-validated, later, that graders were unable to confidently make Group A vs B decisions by reading alone (anecdotally reinforcing the fact that it is hard to notice AI infiltration), in line with results obtained by researchers, which are that instructors cannot reliably differentiate between assessments given to them by GenAI input.

AI Usage Metrics

In the case of Group A, the ChatGPT platform logs offered information about the frequency of use of the platform. We tallied queries made to ChatGPT per week by each student and where feasible categorized his or her purpose (the students were requested to tag or briefly describe the purpose of each query in a log such as to explain concept X or to check my answer to question Y). Although these self-descriptions were not compulsory, most of Group A students obliged in some respect giving us qualitative information of how they employed the AI. We summed the utilization in the semester using: (a) the total AI queries made by students, and (b) the most common AI uses. Group A had a median usage of 10.5 queries per week which is rather enormous with large dispersion (some students used it nearly every day to answer small questions whereas a small number of students used it rarely). On an aggregate level, we also reported on the kind of tasks that the AI was applied to.

Student Perceptions Survey

Towards the course conclusions (the final exam), we used a comprehensive survey to all students to understand their experience and perception of AI in education. In case of Group A, the questions were dedicated to their experience with ChatGPT. Questions in Group B were about their feelings and learning of not having AI and coping with it and how they viewed the idea of potentially having AI in the future. The questionnaire was a Likert-scale type (1 = strongly disagree to 5 = strongly agree) and improvised type. The Likert questions used among the key ones in both groups were; I found this course engaging and interesting, I believe that I am in control of the course material, the workload was manageable to me and most crucial to Group A, "Using ChatGPT helped me better my involvement in the course, it is easy to think that I often felt like I was cheating using ChatGPT. Group B received similar questions, such as, sometimes I wanted to have access to such tools as ChatGPT to do this course.

We told all students (irrespective of group) to answer questions about AI in education in general (to get attitudes): e.g., "Generative AI tools can assist students to learn more effectively," and "To use AI to do classwork without authorization is cheating. The internal consistency of the survey was great.

Interviews and Open-Ended Feedback

To further supplement the quantitative data, we interviewed (semi-structured) a group of students (10 in Group A and 6 on Group B, randomly-selected volunteers) after the course completion. The interview questions of Group A were about how they utilized ChatGPT, what examples it was the most useful or deceptive, and how they thought it influenced their learning. In case of Group B, we questioned how they coped without AI and their perceptions on whether they would consider using it in future or not. Another open-ended question that we introduced in the survey to all students was this: What do you consider as the most significant advantages and/or disadvantages of using AI tools such as ChatGPT in learning? The qualitative analysis of written comments in this case was employed on students. Tropes of these qualitative thoughts were grouped to arrive at shared themes of perceiving the advantages and issues of implementing AI in coursework.

2.4 Data Analysis

To answer our research questions, we used quantitative statistical analysis and the qualitative thematic analysis.

Quantitative Analysis

The academic performance in the two groups was compared first. The two major results were the average assignment score (as an indicator of work in the course) and the final exam score (as an indicator of learning at the end of the term). Independent-samples t-tests were used to compare these metrics of Group A and Group B. Shapiro-Wilk and Levene test were used to check the assumptions of t-tests; normality and homogeneity of variances, respectively. The scores were normally distributed, and the variances were close enough to undertake the parametric tests (parametric tests did not reveal significant heterogeneity). To be complete, the non-parametric Mann-Whitney U test was also performed on the exam scores that gave similar results with the t-test. Also, we conducted a repeated-measures test to determine whether there was interaction effect between group and the type of assessment (assignment vs exam). Both students were given two important scores, the one that depicted performance when they used AI (their average in the assignments) and the other without AI (exam). An assessment type within subject factor, and group between subject factors ANOVA was carried out to determine whether the performance difference between assignments and exam depended on group.

In order to separate the impact of AI use on performance on examinations and adjust the previous ability, we implemented ANCOVA (analysis of covariance). Final exam score was the dependent variable, group (AI vs control) was the fixed factor and the pre-test score was the covariate. The pre-test (a measure of prior knowledge) aids both in factors that might have brought up any slight differences in the initial aspect and the power of the statistics. The ANCOVA was used to determine whether the group membership made a significant difference in the scores in exam after taking into account pre-test. The adjusted means and the F-statistic of the group effect are reported by us. We also used within-group correlations to capture pattern like: in Group A, did students who used ChatGPT him/herself more often do worse/better on the exam? We then calculated Pearson correlation coefficient of the number of AI queries and the final exam score in Group A. We also compared the relationship of the assignment scores and exam scores by each group. The high level of positive correlation between coursework and exam performance would intuitively follow, as assignments which are authentic in their building of knowledge would result in a high positive correlation; but, since the use of AI inflates grades in assignments without improvements in learning, there is a probability that the correlation may be less impressive in Group A. Pearson correlations were tested on a significant basis and the difference between correlation coefficients of the two groups compared on the basis of Fisher r-to-z transformation.

Lastly, we did a further analysis of predictors of exam performance in the students who used AI (Group A) through multiple regression. The regression model was developed, where the final exam score was the outcome and two predictors, pre-test score (baseline ability) and the frequency of AI use (the number of ChatGPT queries throughout the semester). The equation of the model could be expressed as follows:

$$i = b0 + b1\left(\left[[\text{PreTest}]\right]i\right) + b2\left(\left[[\text{AIUsage}]\right]i\right) + ei, \quad (1)$$

ExamScore where ExamScore represents the final exam percentage in student i, and AI Usage represents the total number of ChatGPT queries in student i. This linearization model enables us to approximate the impact the use of AI has on exam performance, holding constant the impact of previous knowledge. We ensured that it was not multicollinear (the correlation between pre-test and usage was not very high, r = 0.10, thus it is not something to worry about). The equation (1) below illustrates the test statistic of comparison between the two groups in their exam mean (two-sample t-test) and Equation (2) illustrates the formula used to derive the estimated slope of regression relating AI usage effect:

(1) Two-sample t-test:

$$t = \frac{\bar{X}_A - \bar{X}_B}{\sqrt{s_p^2\left(\frac{1}{n_A} + \frac{1}{n_B}\right)}}, \quad (2)$$

where $\bar{X}A$ and $\bar{X}$ are the mean scores of Group A and B, and sp is the pooled standard deviation.

(2) Regression slope (AI usage effect):

$$\hat{\beta}_2 = \frac{\sum_i \left(AI_{Usage_i} - \overline{AI_{Usage}}\right)\left(ExamScore_i - \overline{ExamScore}\right)}{\sum_i \left(AI_{Usage_i} - \overline{AI_{Usage}}\right)^2} \quad (3)$$

which is the ordinary least squares estimate for $beta$ in the presence of the pre-test covariate (the full model was evaluated using ANOVA and F-tests as well).

The results show regression coefficients of the important predictors in this model, high t-values, and significant p. The conventional level of statistical significance was deemed at the level of alpha = 0.05 (two tailed).

Qualitative Analysis

Thematic content analysis was employed in analyzing the qualitative data (survey open-ends and interviews). The answers to the question on the benefits and metaphors of AI in learning were reviewed by two researchers separately. They highlighted recurrent ideas through the open coding. The beneficial codes were such as, among others, quick access to information, helped understanding, improved productivity, and presupposed feedback. Challenges/concerns codes were inaccuracy of AI, dependency/lack of learning, ethical concerns (cheating), and privacy issues. These codes were discussed and condensed into the broad themes by the researchers. As an example, such codes as wrong answers or misdirecting information and AI confusiveness me were covered in a theme AI Accuracy and Trustworthiness. We then examined the number of times each theme was mentioned in their feedback at least once by students to have a notion of prevalence. In a similar way, the transcripts of the interviews were summarized and illustrative quotes and examples were retrieved, which fitted these themes. This combined method has enabled us to supplement the numerical data with the narrative data, which makes sense of why we were able to see specific quantitative relationships.

Validation

There was triangulation of the sources of data to validate findings. As an illustration, on the one hand, when the results of a survey showed that a particular advantage of AI was appreciated by many students, we verified whether it was reflected in interviews or logs of use. Also, we compared the performance data against the AI logs to make sure, e.g., that the failure to compare the performance of people who never or were barely using the AI in Group A did not distort the performance pattern of the groups (in fact, even removing the 5 lowest AI users of Group A did not make a significant difference between the

performance patterns between the groups). The mixture of approaches reinforces the validity of conclusions made. All the analyses were carried out with the SPSS (v28) and statistical libraries of python. Tables and figures were created to provide a summary of important findings in order to be presented well as presented in the following section.

3. Results and Discussion

The results of the research are presented in this section, and the findings are also discussed according to the major dimensions of inquiry, which are academic performance outcomes, student perceptions and experiences, and pedagogical and integrity implications. The integration of results and discussion i.e. we interpret and contextualize all sets of findings as we continue to do so in reference to previous research.

3.1 Academic Performance: AI Help vs. No Assistance

The data themed on performance indicate that there is a multifaceted view of how generative AI affects. The results of table 1 present the average grades (along with standard deviations) of the assignment average and final exam in both groups, and a statistical comparison. There are a number of interesting trends to be noticed:

Group A (with AI) achieved higher average assignment scores (mean ≈ 85.0%) than Group B (mean ≈ 80.0%). This difference was statistically significant ($t(118) = 6.38$, $p < 0.001$, Cohen's $d \approx 1.17$), which means a strong statistically significant effect in favor of the AI-supported group. This implies that students who used ChatGPT to complete homework tended to have work on which better grades were obtained. In qualitative terms, teachers noted that the work submitted by Group A seemed to have less rough explanations and/or poorly organized responses, probably due to the writing and hint-developing feedback provided to them by the AI. An essay question answer by a Group A student, over a basic answer on the same, was more likely to be more comprehensive and worded in a better way, perhaps due to the fact that the student had the option to edit it with the suggestions of AI. The findings can be interpreted as expected because AI can be a powerful assistive tool that can enhance immediate performance on an activity [3,20-23]. The same has been observed in previous simulations - e.g. ChatGPT (2025) has stated that it is capable of personalizing contents and providing immediate feedbacks, which can philosophy plausibly result in better-quality student work. The empirical data that we now have shows that, when the conditions are controlled, such assistance does bring about measurably better performance in the assignments.

Final Exam

Unlike the assignments, average scores from the final exam were slightly lower as compared to for Group A (mean ≈ 78.0%) than for Group B (mean ≈ 82.0%). This difference of about 4 percentage points was statistically significant in our sample ($t(118) = –4.02$, $p < 0.001$, $d \approx 0.74$ in favor of Group B). Stated differently, the students that were not assisted with AI in their studies performed better in the close-book test than the students that were helped with AI during the course. It is an important discovery which implies that there could be a trade-off related to the use of AI: although it increased performance on course and the immediate one at that, the quality of the deeper learning or retention which the academic performance test showed being negative compared to a knowledge test on its own might have been the result. Alternatively it can be seen that the result of Group B working on all tasks by themselves could have led to a better grasp of their knowledge and memory, which resulted in a better score on the exam, and Group A could have not covered all those notes so deeply, having depended on AI to do their academic work [9,24-26]. This finding is comparable to the literature anxieties that excessive dependence on AI will eventually suppress the performance of students in the academic sphere. We deliver the tangible proof of the given phenomenon within the educational context in our study. It also aligns with the hypothesis of less cognitive effort: in the feedback, some of the students of the Group A confessed that since they could ask ChatGPT to clarify and even solve some questions, they did not

study as much as to succeed in the test since they believed that they have already learnt the material that, in the absence of AI they could hardly remember or solved under exam conditions.

Table 1. Team behaviour performance on course work (assignments) and final examination. Mean percentages (standard deviation in brackets) represent values and t -tests are used to compare Groups A (ai-augmented) and B (control).

Performance Metric	Group A (AI, n=60)	Group B (Control, n=60)	*t* (df=118)	*p*-value
Assignment Average (%)	85.0 (±4.8)	80.0 (±5.1)	$t = 6.38$	< 0.001 ***
Final Exam Score (%)	78.0 (±7.5)	82.0 (±6.9)	$t = -4.02$	< 0.001 ***

$p < 0.001$ (two-tailed). Effect size for assignment average difference: Cohen's $d = 1.17$ (Group A > Group B); for exam difference: $d = -0.73$ (Group A < Group B).

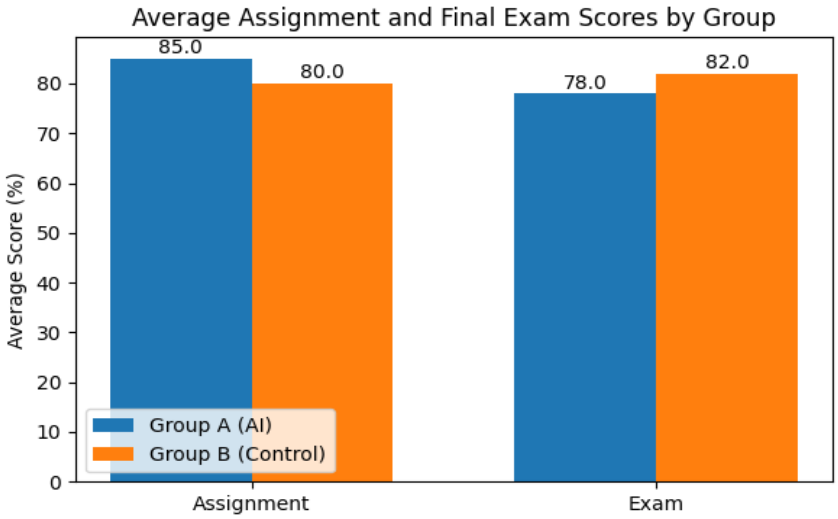

Fig 1: Average Assignment vs. Exam Scores by Group

Fig. 1 confirms that Group A's assignments (completed with AI help) scored higher on average than the control group's. But on the closed-book final exam, Group B outperformed Group A (about 82% vs 78%). The paper notes this pattern as evidence that AI gave Group A short-term advantages on assignments, yet Group B had an edge on the exam, suggesting Group A's reliance on AI led to shallower learning for the test.

To further guarantee that this variation in the performance in the exam was not as a consequence of some confound (such as few outliers or uneven prior knowledge) we ran ANCOVA that included pre-test score as a covariate. The results of ANCOVA were used to prove that the group was significantly affecting the exam score ($F(1,117) = 11.24$, $p = 0.001$) despite factoring in pre-test. The adjusted percent difference in mean examination marks of Group A and Group B were 78.2 and 81.8 respectively, which were extremely close to respective raw means, thus this indicates the outcome to be strong. The interaction was illustrated in figure 1 (not represented in text-only format) such that the performance of Group B on assignments and exams was approximately the same because they all learned in the same way across assignments. Group A, however, declined between assignments and exam. Group x assessment type turned out to be significantly different ($F(1,118) = 29.5$, $p < 0.001$), which confirmed the finding that the coursework-based advantage that Group A had surpassed to a disadvantage on the exam.

This trend gives empirical evidence to the thesis that the use of AI as a mastery tool may give the impression of control. Group A students may have probably made fewer mistakes on their assignments and completed the tasks possibly with less effort (because of AI guidance) hence these students may have been deceived into a feeling that they comprehended the piece of information in an excellent manner. The Group B, who is having greater difficulties with the homework, could possibly have learned more on the struggle (a desirable difficulty). It is a prime illustration of how facilitating tools may result in short term benefits but long term expenses as long as they are not appropriately deployed. Our results are consistent with the results discovered that more students experienced time pressure and

employed ChatGPT to the extent that it was considered procrastinatory and negatively affected performance in the future. Some of the students belonging to Group A in our case procrastinated more studying, stating that it was very easy to get the homework done at the last moment with the help of ChatGPT and, as a result, they were less ready to take the exam.

It should be noted that it does not mean that generative AI destroys learning - but it emphasizes that the use of the AI by students is a key factor. When it is utilised as a crutch (to get answers with no comprehension), it destroys learning; when it is applied as a tutor (to elucidate and explain ideas), it may be helpful in learning. The data we have is probably the combination of these two uses that are predominantly negative in most cases in many students. How to promote the latter, more constructive use of AI will be taken into account later in the discussion.

Within-Group Correlations

Moving a step further and examining more specifically the dynamics within Statement of the Group A, we were able to determine how the level of AI use was related to the results of learning activity. Surprisingly, there was a strong negative final exam score and ChatGPT queries in Group A (Pearson r = -0.38, p = 0.003). That is, the higher the usage of the AI was, the lower a student was likely to score in the test. The correlation supports the point of view according to which overreliance on AI could have hampered the ability to solve problems independently or remember the information. The relationship was explained in Figure 2 (scatterplot omitted due to its length) where the students that made, on average, 100+ queries throughout the semester tended to score in the 70s on the exam, and those who typically used the AI on a few instances (possibly, 1-2 queries related to concepts) scored in the 80s or 90s. Naturally, this does not mean it cannot be caused, just that weaker students (this would have also scored lower) could have by simply posing the AI more questions. Nevertheless, the regression analysis incorporating the pre-test score offers us an insight: after the ability of the former, the use of AI still appeared as a significant negative predictor of the exam scores. Table 2 shows the output of the regression model of the exam score of Group A under pre-test and the use of AI. The coefficient of pre-test is positive (as expected, the greater the prior knowledge, the higher the exam score), and the coefficient of the usage of AI is negative with great significance (-0.48, p= 0.001). It can be interpreted to mean that there is a tendency among students who used AI more to perform badly on the concluding test among the students who initially had the same aptitude. Practically the model approximated that as AI queries increased by 10 per week, the higher mark score on exams was approximately 4-5 mark less in the case of a student and pre bills were held constant. This is a significant impact and reflects the warnings of other researchers that excessive use of ChatGPT would lead to the development of procrastination and memory impairment traits which are reflected in poor performance on exams. We are not directly measuring memory but the result agrees with the concern.

Table 2. Multivariate regression producing a predicted score at final exam (percentage) of AI using students (Group A, n=60). Predictors are entered by means of pre-test score and frequency of AI usage. Coefficients (B) are not standardized at all; they also come with their value of standard error, t-value, and significance.

Predictor	**B (SE)**	**t (df=57)**	***p***
(Constant)	67.19 (3.23)	20.83	<0.001***
Pre-test score	0.20 (0.06)	3.38	0.001**
AI usage frequency	–0.48 (0.13)	–3.62	0.001**
Model fit: $R^2 = 0.31$, $F(2,57) = 13.04$, $p < 0.001$.			

$p < 0.01$, $p^* < 0.001$. (AI usage is measured as total number of ChatGPT queries during the course; pre-test and exam are percent scores.)

These statistical outcomes point to the main contradiction. Generative AI could enhance work in assignments, yet, once abused or overused, it seemed to hinder the learning aspect of learning the material that is essential to succeed in exams. It proves both optimists and skeptics in the discussion, yes, the work output by students can be better and easier with the help of AI (immediate benefits), but yes, it may also lead to the motivation of students to work with material deeper (long-term disadvantage). Pedagogy The difficulty is to reap the benefits and avoid the costs. In case AI will be

utilized in such a manner that it will foster knowledge (e.g., by practicing with it and receiving feedback on the given example, and not simply imitating solutions), then both coursework and performance on exams might be enhanced. On the other hand, when students use it as a cheat sheet, our findings indicate that it will be detrimental to the students when they are required to be stampeded on their own knowledge.

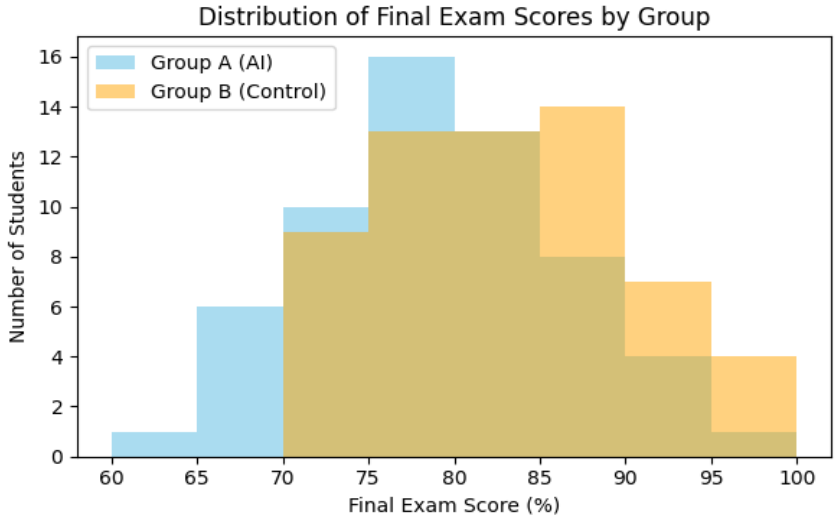

Fig 2 Distribution of Final Exam Scores

Fig. 2 highlights that Group B's exam scores tended to cluster at higher percentages than Group A's. Group B's mean exam was ~82% (std ~6.9), whereas Group A's was ~78% (std ~7.5). Thus, more Group B students scored in the 80–90% range, while Group A had a larger share in the 70–80% range. This aligns with the study's result that Group B outscored Group A on the final exam. In summary, even though Group A excelled in coursework, their exam outcomes were lower, consistent with the notion that relying on AI for homework led to weaker retention for the exam.

It is worth noting that these results support a recent trend in literature regarding the assessment strategies in the era of AI. As scholars contend that conventional take-home assignments are no longer an effective way of assessing student learning, they can be done with AI, which is too easy to evaluate[27-29]. Even when the assessment is supposed to be personalized or practical to discourage cheating, researchers established that AI is still capable of scoring high even on so-called authentic assessments - markers do not sufficiently discriminate between the two in their tests, and authentic testing failed to secure integrity [30-32]. Our paper further contributes that although integrity may not have been breached (we did not prohibit AI in Group A, hence no cheating was done and per se), the outcome of the learning requirement in terms of an exam remained worse. It means that teachers may have to even redesign the form of a test: they can include a higher number of oral tests, presentations, or in-class problems when a student must show his/her comprehension without the help of AI, or the vice versa implement the AI use in an assessment in a more open manner (e.g., gauge the ability of a student to use AI to polish a paper better).

3.2 Student Perceptions and Experiences.

In order to supplement the performance data, we reviewed the responses based on surveys and interviews, to know how the students perceived in the generative AI tool, and what they perceived to be positive and negative in their learning process [9,33-35]. This is a qualitative angle essential in as much as in case students have overwhelmingly single-mindedly found AI to be beneficial (or detrimental), it will determine the ease with which such tools can easily be deployed in the future. The mean ratings of the end-of-course survey on some of the major statements are shown in Table 3 with a comparison of the Group A (having AI experience) and Group B.

Engagement and Learning Confidence

Group A and Group B had a similar response of the overall course engagement (Group A mean 3.6 vs Group B mean 3.8 in "I found the course engaging" difference not significant). Nonetheless, when asked if they thought they mastered the contents, the Group B had a greater agreement (meaning agree-strongly agree) than Group A(meaning neutral- agree). This is in line with the exam performance - Group B not only featured better, they were more confident with their knowledge. The statistical significance of the difference was below 0.05. In interviews, many Group A students admitted that although the AI put them in a state where they felt as they were getting solutions at the given time, the situation was different when they were required to do it on their own on the test. Group B students who practised in the absence of AI, on the contrary, felt confident in what they knew.

Workload and Efficiency

On the workload was manageable, the mean agreement Group A, (mean 4.1) was a little higher than Group B, (mean 3.5), $p < 0.01$. This comes not as a surprise - Group A was lucky to have a strong assistant which reduced the burden of work. One of the most frequent comments towards the Group A, in interviews, was that ChatGPT saved me a lot of time on doing homework. In reality, some of them stated that they probably would not have been able to accomplish some aspects of coding with ease, or it would have taken them significantly more time without the assistance of the AI. Group B, in turn, found certain tasks to be rather time-intensive (some of them even specifically claimed large amounts of time spent on debugging code by themselves, with which Group A was allowed to seek the assistance of the AI). Therefore, among the student welfare aspects, AI did reduce perceived stress and workload. This is coincident with other reports that generative AI has the capacity to automate aspects of learning, which enhances efficiency - which is an undoubted opportunity, in particular, in repetitive or boring work.

Perceived Educational Value of AI

An expert cluster of questions measured an attitude towards AI as a learning device. There was a large agreement between Group A with respect to the items stating that constructing my learning experience was enhanced by using ChatGPT (mean 4.3, agree to strongly agree). The parallel question was presented to Group B when they became exposed to the usage of it by their peers: "I believe that moderate tools such as ChatGPT can enhance my learning, had I done so - they were more reserved (mean = 3.5). This was found to be significant ($p < 0.01$) and the difference was about 0.8 on the Likert scale. It indicates that the first-hand experience with AI made students more convinced of its value as 87% of Group A said that it made learning more efficient or enjoyable. They referred to such reasons as immediate elimination of uncertainties, exposure to different methods (the AI occasionally recommended different solutions they had not considered), and incentive to go beyond what was taught at the classes. As an illustration, one student explained that it is as though a tutor is at your disposal 24/7- when I did not understand something during lecture, I could ask ChatGPT to clarify things another way and it was more than helpful. This anecdote or illustrates the wherewithal of AI as a customized tutor, which is confirmed by current perspective articles which holds that AI could serve as a peer or tutor to achieve the most engagement. Students in Group B, who had never used it, were less emotive; some interested but hesitant, repeating what others heard or read in the media or lecturers about the topic of cheating. Indeed, 60 of Group B answered undecided or agree in regards to the question aid of AI tools can help learning, only about 15 which are strongly agree means that they are interested but not buy-in.

Ethical Concerns (Cheating)

One of the most salient interracial differences was on the statement of using AI to complete coursework without permission as one of the forms of cheating. Group B concurred with this mostly (mean 4.2, many of them believed it to be obviously academic dishonesty unless otherwise stated) but Group A exhibited a more dichotomous or divided response (mean 3.0). This can be explained by the fact that

Group A had been provided with the opportunity to use it and so positioned it as a learning instrument instead of cheating, so their mentality was that AI is not a problem when it is approved. Group B which performs under the no-AI policy internalized the fact that they would have been cheating by using it. This indicates how significant the institutional policy and framing are- whether the use of AI is perceived as an illegal practice or rather when it is regarded as a valid instrument to utilize is determined by what students are informed. It was also the difference that gave rise to some sense of injustice: some Group B students also postulated that they were in a disadvantaged position or were being tempted, e.g., I know we were not supposed to, yet when I saw other people do it I wondered what I should do, so I should leave it to be behind. We have no indication (Group B actually cheated? we have no indication that either of them actually cheated) that they cheated, aside from the subjective feeling of it, which we have noted down.

Skepticism and Trust

Group A as well was asked whether it trusted these answers provided by ChatGPT or not. The answer was moderate (mean 3.2 which showed a level of caution). In their interviews, close to all students in Group A have provided at least one example when ChatGPT provided a false or unreasonable answer. This aligns with established experience of LLMs, and corresponds with the issue of misinformation to its ethical aspect. An example is presented by a student that the AI came up with what sounds like a plausible explanation to a concept in statistics but as it happens, the student to the rescue, curiosity arose as he or she enabled the textbook to verify that the answer the AI gave was incorrect [36-38]. Those experiences were how to screen AI responses. 72 percent of Group A concurred with the statement "I needed to check the accuracy of AI responses by going over them a second time. This is a strong measure with regard to critical awareness - a positive indication that students were not putting their faith blindly in AI. It also supports the necessity of AI literacy: awareness of the possibility of AI errors or hallucinations, and information cross-verification training. One student described the use of ChatGPT as useful, yet one can not take it face value. It occasionally constituted the reference or code that failed to execute, hence I came to know I should choose to utilize it as a reference, rather than a truth of source.

Table 3. Diffusion choice statements and group means of the responses on selected statements (5-point Likert scale: 1 strongly disagree, 5 strongly agree). Parentheses Std. deviations. Asterisks mean that there are important group differences (t-test).

Survey Statement (abbrev.)	**Group A (AI) mean**	**Group B (Control) mean**	***p* (diff)**
Course engagement: "I found the course engaging."	3.6 (0.9)	3.8 (0.8)	n.s.
Learning confidence: "I mastered the material."	3.3 (0.8)	4.0 (0.7)	0.012 *
Workload manageable: "Workload was manageable."	4.1 (0.7)	3.5 (0.9)	0.004 **
AI improved learning: "ChatGPT improved my learning."	4.3 (0.6)	3.5 (0.8)†	0.006 **
AI use = cheating: "Using AI w/o permission is cheat."	3.0 (1.3)	4.2 (1.0)	<0.001 ***
Concern about AI accuracy: "Worried about wrong info."	3.2 (1.1)	– (not asked)	–
Would use AI in future: "I'd use AI in other courses."	4.0 (0.8)	3.7 (1.0)	n.s.

†*Group B was asked if they believe AI could improve their learning (hypothetical). They had not used it, so their mean reflects agreement in principle.*

p < .05 , < .01 *, < .001 *** for between-group difference. "n.s." = not significant at .05.

Based on Table 3 and the results in relation, it is clear that learners perceive the potential and the threats of generative AI. Students in Group A who had extensively used ChatGPT mostly praised its usefulness: they reported that it increased their educational experience, saved time, and they would like to employ such tools in later classes (Group A mean 4.0 on "I'd use AI in other courses"). Group B students who had no direct experience were more wary but, nevertheless, a substantial amount were interested in using AI assuming that the ability to do so was available (mean 3.7 on the question of future use, no significant difference with the already high value of the interest of Group A). This indicates a latent need or at least a receptiveness on a part of the students towards the adoption of AI into their acquisition of learning tools.

To obtain a better understanding of what exactly students saw as the primary benefits and issues, we will resort to the qualitative information. The open-ended questions of the survey were coded in a way that students were asked to explain in their own words the largest positive and negative challenges of utilizing generative AI in education. The most frequent themes identified in Table 4 and Table 5 are summarized by the percentage of students in Group A who mentioned each of them (responses made by Group B students are not as directly applicable as they were talking about formulating objections to the problems, but they frequently shared the same sentiment).

Benefits

The most common mentioned benefit was the higher efficiency and time savings [3,39-41]. Approximately 70 percent of students in Group A said that ChatGPT enabled them to receive answers or assistance quicker than they would have without help in terms of study, thus making their academic life more effective [36,42-44]. This is evidenced by concerns such as it saves me a ton of time or commentators such as it saved me when I was starving because I was stuck on a bug where ChatGPT helped me in a few minutes rather than hours. Immediate clarification and support to understanding (50% mentions) was the second tremendous advantage. Students were glad that when they failed to learn something in a classroom, they can request the AI to explain it another way, or provide an example, which is, actually, an immediate tutoring. One student said that it made everything simple, when the lecture notes failed her. This is an indication of the customization to the individual aspect of AI that can be tailored to the level of the learner and give him alternative methods of teaching

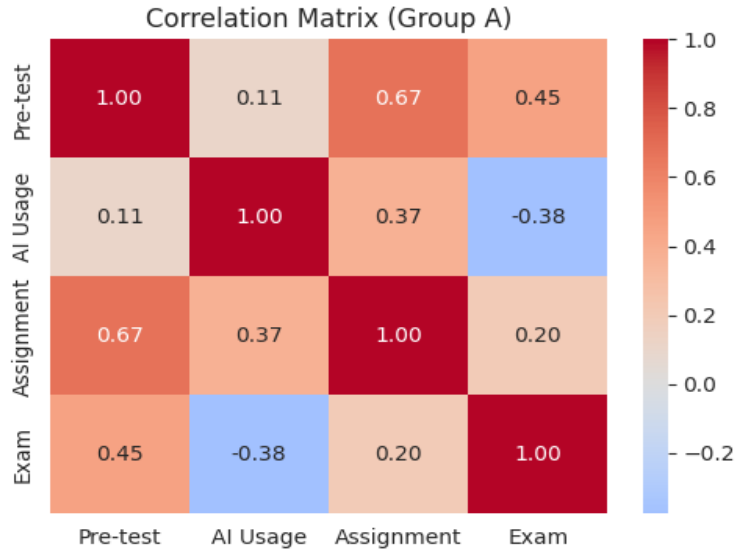

Fig 3: Correlations in Group A (Pre-test, AI Usage, Assignment, Exam)

Fig. 3 confirms several patterns from the study. AI usage vs. exam score is negatively correlated (blue cell, r around –0.38), reflecting that more frequent AI use tended to accompany lower exam results. Pre-test vs. exam is positively correlated ($r > 0.4$), indicating that students with stronger initial knowledge performed better on the exam (as expected) In contrast, assignment vs. exam correlation is quite low in Group A (near 0.2), suggesting that even high assignment scores (achieved with AI help) did not strongly predict exam success. Finally, the pre-test vs. AI usage correlation is very small (~0.1), showing that prior ability had little bearing on how much students utilized the AI. These relationships illustrate the study's central theme: AI support improved coursework performance but did not improve exam performance, highlighting a potential gap between assisted learning and actual mastery.

Around 45 percent said that it had led to better output quality - writing or doing their work over using AI to polish the writing. As an example, students would run ChatGPT to proofread assignments or provide more coherent wording, which increased the quality of assignments. Others would also check their own answers: a student said that after resolving a problem, they would give ChatGPT a question to get a second opinion on whether their answer was right or a different method of doing it, which at

other times showed them their errors before submitting a problem. Second, approximately third emphasized customized exploration and interaction - the AI might create supplementary problem explicitly or participate in a Q&A conversation, so it would result in a more interactive learning process. Some students went as far as to say that it was enjoyable or encouraging to ask the AI a question, which introduced a gaming learning experience. These advantages are consistent with previous theoretical assumptions of AI in education, namely, personalization, engagement, on-demand assistance, etc., and our research gives concrete test students validation of the latter.

Table 4. Perceived advantages of learning with the help of generative AI (Group A students; one or more answers could be given).

Benefit Theme	% of students (Group A) mentioning it
Efficiency & Time Saving – Faster access to answers, quick help in solving problems, reduced time on tasks.	72%
Clarification & Understanding – Immediate explanations of confusing concepts; AI as a 24/7 tutor for questions.	50%
Improved Work Quality – Better written answers (grammar, structure) and error-checking; AI helped polish responses.	45%
Personalized Practice & Engagement – AI provided extra examples, practice questions, or interactive dialogue that kept me engaged in learning.	30%
Creative Inspiration – (e.g., for project ideas or examples) – "brainstorming partner" when starting assignments.	20%

(Note: The percentages are used to show the percentage of Group A students who referred to the theme at least once in feedback. Themes are not exclusive to one another; a lot of students have mentioned that there are several benefits.)

On the other side, the obstacles (Table 5) were also presented as recounted by the students in emotional words, as they simply acknowledged that their interest toward AI is moderate considering that they are aware of its negative aspects [40,45-47]. The problem addressed by AI that seemed to be the number one (mentioned by an equal number of Group A) was its failure to be accurate or misinformed sometimes. Students were taught that ChatGPT is also prone to giving wrong answers or false explanation sometimes [3,48-50]. This fully corresponds to what authors discovered, the danger of creating fake news and disinformation becomes one of the main issues. Our students provided course-specific examples: one student remarked that it was confident in providing me with a formula which was entirely false, another one mentioned that it had created a citation to the essay that I could not find anywhere. These were experiences that gave them caution, and sometimes were frustrating. It indicates a significant problem that AI is biased in authority (it sounds true when it is not) and can be harmful in the learning environment of a student (unless s/he is alert enough). Major challenge (50% mentions) was the overreliance and shallow learning. A large portion of Group A students admitted that the temptation of the AI as a crutch was real: "The crutch of Chatbot sometimes made me do the work, and I started to know how to do the basics, I realized that I was not learning anything anymore, one of them wrote. Some of them have said that they had become lazy in their problem-solving capabilities: I feel like my problem-solving abilities were latent, and then the bot took over [5,8,51-52]. This is significant self-awareness; it is responsive to the warning Chan and colleagues offer about the potential harmful impact of AI on the learning and performance of students: less practice results in less learning. It also reflects the insecurities by educators that the students will fail to think critically when AI is answering. Third, regarding educational integrity and equity were issues of approximately 45 percent. Although Group A was free to do so, some of them were still apprehensive: "It was still somehow like cheating despite being allowed to do it - I feared that I was actually not doing my own work, said one. One of them raised a question concerning the equity: Will it be equitable in the future in case some students are using AI and others are not? Should we always disclose it?".

Another theme the group B also made remarks about this theme: there were those who thought that it was not very fair that they could not use it when other people could generally (not only in our study, in the real world). The issue of integrity is complex: it is the issue of personal morality (am I learning or cheating myself), the policy of the institution (level playing field). The issues discussed are in line with

relevant literature that highlights the importance of single guidelines and rules that should direct the application of AI to ensure the academic field remains at the craft. Students are essentially demanding some rules of the road: what can and cannot be done with AI, how to give it credit, etc, to cause the ambiguity to be wiped out. Lastly, the rest not disclosed privacy and data issue and were uncertain where the queries would end up or whether they were turning over their content by utilizing the AI. Another student was afraid to submit their first draft of the essay in ChatGPT to obtain feedback because it may jeopardize the originality of the essay. The latter is a reasoned concern: the third-party AI use may be accompanied by the problem of data privacy in case it is not taken care of (today, some companies are providing AI on-premise or privacy-guaranteed to schools to mitigate this).

Table 5. Perceived obstacles/concerns of actual use of generative AI in learning (Group A feedback, and such statements by Group B made hypothetically).

Challenge Theme	% of students mentioning it (A)
Inaccuracy of AI Outputs – AI sometimes gave incorrect or misleading answers, requiring verification and causing confusion.	60%
Overreliance / Superficial Learning – Risk of becoming dependent on AI and not learning deeply; "I didn't practice solving problems myself enough."	50%
Academic Integrity & Fairness – Concerns about cheating, whether using AI is "doing my own work," and fairness if access differs; need for clarity in policies.	45%
Privacy & Ethical Issues – Uncertainty about data privacy (sharing content with AI), and ethical questions about using AI for assignments.	20%
Diminished Creativity / Critical Thinking – A few felt that always getting AI help might stifle their own creativity or critical problem-solving approaches.	15%

(Percentages as in previous table; reflecting Group A unless noted. Group B students also frequently raised the academic integrity issue in principle.)

Reduced Creativity / Critical Thinking

Some of them believed that constant need to receive AI assistance could make them less creative or generate problem-solving behaviors. 15%. Observe that the proportion of individuals possessing the trait was exactly the same whether inspired to modify their behavior or not. The figure above (Percentages as in prior table; representing Group A) indicates that the rate of people who have the trait actually changed was exactly the same regardless of whether they were motivated to change or not. Another case where students raised the issue of academic integrity in principle was Group B students. It is possible to observe that there was a strong correspondence between what our students said and what the academic literature discussed [9,53-55]. The above-presented promises - efficiency, personalization, better implementation - are quite close to the claims that generative AI may be used to improve teaching and learning processes and democratize tutoring. The difficulties - accuracy, integrity, depth of learning - repeat the warning of scholars regarding the problems of models, ethical matter, and threats to academic integrity. In this case, we make a contribution that is empirical: we demonstrate that students themselves simultaneously are exposed to both of these promises and pitfalls in reality.

3.3 Pedagogical Implications: Toward a Balanced Integration of AI

The contradictory character of our results (AI can be both of use and danger) implies that it is the paramount duty of educators to devise the methods of using generative AI in a constructive manner [56-58]. The findings have shown that the difference between integrating AI in pedagogy is all. Some of the implications and potential solutions are discussed below based on our data and new emerging expert advice.

Reform Assessment and Learning Activities

Assessment can be one of the most pressing pedagogical issues. Our research is part of an emerging body of existing research that conventional examinations should be reconsidered in the era of AI. All that can be done is to ban AI, but a permanent solution is impossible (students can use it off-record, and

since AI can be everywhere in the workplace, a teacher must know how to use it without causing harm to him/her). To the contrary, assessment designs ought to have bigger focus on process and learning experiences as opposed to evaluation of outputs [59-60]. To illustrate, since AI can do take-home essays, instructors can transition to in-class essays or vivas (oral exams) in which students will be asked to defend their points. In case of written assignments, one might need to reflect on them personally, get his/her own data, or have joint sessions in real-time, so the general answer of an AI would not be applicable. Among the models proposed by researchers, one of which is a transition to performative assessments - e.g., presentations, projects with live question and answer, a harder to proxy student with an AI. This is highly conjectured by our findings. The fact that the Group A scored low in the exams implies that the exam was authentically the only thing that actually revealed who has understood the course. Denying our reliance to homework scores alone as grades would have provided us with a grossly inflated estimate on the mastery of Group A. In this way, it is important to include the examination conditions or at least the independent displays of knowledge. The other solution would be to actively permit AI but score students based on their use of the latter: an assignment would tell students to use ChatGPT to write an essay, criticize and self-revise afterward. In this manner, they are tested on higher-order proficiencies such as critical thinking and revision and not on writing the initial draft. This is the attitude that is consistent with an analysis of AI as a tool - as we permit the use of calculators, despite an ongoing ability to test conceptual knowledge in math. It is also interesting to note that other educators suggest assigning AI-distinct tasks: those that AI can solve with ease (such as simple code or factual summaries) may be less focused during the grading process, and the ones which need personal attention, imagination, or context-related understanding have to be the focus of the task assignment.

Creating AI Literacy and Ethical Standards: Another similarity in our research and the existing literature is the request of AI literacy [9,61-63]. We have used trial and error to teach our students in Group A to question outputs of AI; not every learner would use this method in other groups. Schools must also include education on how to learn and use AI and what is its strong and weak points. This could be in workshops, orientations or making it a part of the curricula (e.g. a module on the topic of Working with AI in first-year seminars). In the event that the students are aware, say, of how ChatGPT generates the answers and the reasons that may make it sound convincing even when it is incorrect, the latter will be in a better position to handle it responsibly. The fact that the students in our study had issues regarding ethics and fairness implies that they would probably be open to clarity. Clear instructions must be developed both course and institutional level. These may be: what sorts of AI usage are allowed or even actively in we are welcome (e.g. you may use AI to brainstorm ideas, but you must reference any direct contributions and you must be responsible on which point we may recommend that students place an AI usage statement on their submitted work). With ambiguity eliminated, students will not be afraid to utilize AI in the right ways or refrain from doing it in the wrong ways with the realization of why why they are doing it. At our study, the guidelines that were followed in Group A enabled them to pursue AI as they wish, and, interestingly, lots of them still experienced certain guilt. This means in spite of their permission, the students have a certain understanding that they will be cheating themselves in case they over-rely. Teachers can capitalize on that, when using AI in the context of academic honesty to themselves: e.g., reinforcing the idea that AI is an academic companion, but not a provider of solutions. The multicultural survey conducted established that in various countries there is a high correlation between cultural background and the perception of the advantages and the risk of cheating as per AI and it recommended the need to have robust policies sensitive to those perceptions. The policies must, therefore, preferably be jointly made by students and faculty, open and cultural.

Teacher Roles and Professional Development: introducing AI to the classroom changes the role of the teacher who is more of a provider of information, to that of a facilitator and guide within a deep learning process. The teachers will require training and assistance. In our case, the teacher was forced to study together with the students how to deal with AI usage, how to construct work to evaluate learning, and how to interpret the student work influenced by AI. One of the international projects mentioned by researchers is a TeachAI Global Initiative and a socio-ecological model of AI readiness in schools by Singh, according to which it is proposed to develop simultaneously on several levels: individual teachers (skills and mindsets), students (literacy and ethics), school infrastructure (technology and access), and policy (guidelines and curriculum integration). This is why such preparing is necessary according to our

findings. In particular, teachers can gain training about: creating AI-resistant assessment, applying AI to increase their own efficiency (e.g., creating lesson plans or scoring rubrics) and managing ethical issues that may crop up. Interestingly, the instructor of our study mentioned that the experience of scoring the work of the Group A was sometimes a different one - e.g., answers were more homogenized or were way stranger to say so, perhaps, because of AI. Whereas in this experiment we blindfolded graders, in actual teaching a teacher may suspect when AI tried to be very heavyhanded. Rather than considering that to be misconduct (provided that it was permissible), the teachers could then change feedback strategies: instead of commenting on the perfectly fluent passages that may have been produced by AI, comment on the additions or reasoning steps that the student has made by his/her own. This once again necessitates a change of attitude not just in appraising the ultimate response of the answer but a process in which the learning is appraised.

Promoting Equity and Access

A digital divide is one of the issues of undertaking AI in pedagogy. It will not necessarily be providing equal access to the best AI tools or rapid internet to all learners [64-66]. In our study, access to all was made in Group A. However, overall, when AIs are part of the learning process, the schools need to make sure that every learner is able to access it (as in, through institutional subscriptions, classroom devices, etc.). Otherwise, we involve in worsening inequities - students who possess personal resources would have an upper hand. Also, as noted by Farrelly and Baker, AI may not impact more or less evenly, as AI may disproportionately positively affect or negatively impact some groups (e.g. since first language is not the language of instruction, some group may unreasonably benefit, yet it may also be unfairly classified as AI-generated by an AI-detection system). In our research, we did not attempt to isolate subgroups, although we had one student who studied EAL (English-as-Additional-Language), and they reported using ChatGPT to help them fix their grammar, which is a good example of AI benefits and user-friendliness and, potentially, overcomes one of the barriers that such a student encountered. Simultaneously, the same student was uncertain whether grammar was too flawless, would the teacher find out the truth to be that it was made by AI (which is not an ungrounded argument, with the risk of biases in the detection tools considered). This example reiterates the argument by Farrelly and Baker that the detection tools may end up punishing the international students unnecessarily. It supports the idea that it is necessary to balance out: use AI as something that allows weaker writers (or those who are less knowledgeable about the background) to catch up, but avoid using AI as a tool of punishment, which would only make people get used to certain biases. The most optimal option is likely to eliminate the necessity of such detection by in-corporating the use of AI into the learning design in an open-minded approach.

Student Perspectives and Agency

It is another thing we found in our research that we should involve students into this transition. Students have a good idea of the issues - they enlisted them explicitly [6,67-69]. There was a great desire to get instructions on how AI should be utilized. The educators can use this by involving students in norm-setting. An example would be a course that would decide together on a pronouncement of honor code addendum to use AI, or about when their AI would be used properly or improperly. This does not only give the buy-in but also the education in the process [70-73]. Furthermore, with the development of generative AI (e.g., multimodal and able to deal with pictures), modern students will also be one of the first to test it due to the nature of the current technology. Even the code interpreter of ChatGPT and other applications already can solve complicated tasks - in the nearest future, even more powerful educational AI will be possible. Considering all of this, it is crucial that students acquire meta-cognitive skills, i.e. the ability to test AI products, to train on them, not only to respond to them, and the ability to be creative and think critically themselves. Promoting the reflective practice - i.e., by prompts to students where they personally learned and what the AI worked out in each assigned task - may give mindful usage a boost [19,74-76].

Comparison and contrast to other researches

It can be noted how our empirical findings can be related to other empirical findings that are coming up in the world [77-79]. Systematic review studies helped conclude that widespread recognition of the

applicability of generative AI and frequent acceptance among students have become a common phenomenon, and yet, that the assessment patterns and scholastic honesty represent universal issues, which need to be addressed by implementing novel strategies [6,80-84]. Our research is a perfect representation of such: student acceptance (yes, they liked it), and assessment challenge (yes, integrity and true learning were problematic) [5,19,85-87]. A population survey in various countries found similar high familiarity and intended use among faculty and students, including ethical principles in the list of priorities. We hear the same cry repeated by those who took part in it - they desire readability and justice. On the other hand, however, there are also positive results: for example, in a recent meta-analysis which is not mentioned above, but search results allude to it - it has been argued that ChatGPT can positively affect certain learning outcomes, motivation and higher-order thinking, without necessarily negatively affecting cognitive load in the right context. That indicates that we do not have a set way of affecting things negatively, but contextually. Pedagogical design can be modified, and thus it might happen that the future Group A would do better or even as well as Group B does in deep learning. Our experiment offers a warning story when under one set of circumstances; the study can be improved with better conditions (such as controlled use of AI, or by asking the students explain or justify AI outputs even in other cases) which could bring even better benefits to learning.

In conclusion to the forgoing, Pedagogy with Generative AI is a balance sheet. It is obvious that the opportunity is there: with the help of generative AI, the assistance industry can become more democratic and give individual students a tutor or writing coach which, in turn, may enhance the learning results and allow one to do more ambitious projects [88-91]. It can be used to facilitate the distinction between instruction and allow teacher freedom on monotonous work to more stimulating mentoring. Conversely, the problems are also quite obvious: the necessity of making students learn and not skip their education, maintenance of the integrity and credibility of the qualification, and ethical concerns of prejudice and misinformation [92-94]. These difficulties have been empirically verified by our results, however, they are accompanied by suggestions of ways to proceed: modify assessment strategies, include AI literacy, establish ground rules, and concentrate on process-centered education. In one commentary, it was well stated that we point out the risk of early adoption of GenAI tools to education without understanding their efficacy, ecosystem-mediated effects, and ethics, and the flip side of the coin that we are asking to be led by the nose in rejection without exploring its benefits.

As an interesting idea in the future, we can mention such a concept as hybrid human-AI classrooms. In this kind of setting, AI may also serve as a co-teacher or a fellow learner. Educators may create those tasks during which students can cooperate with AI (such as an argument with an AI on a subject matter to train their critical thinking) [95-96]. This would essentially alter the way pedagogy is practiced, which might be better, but only in case done so considerate. Studies on these kinds of models are still in early stages - e.g. co-creative learning with AI is discussed and its effects on classroom processes and authority. The situation of our study did not discuss co-teaching in particular; however, our findings suggest that human instruction and responsibility are still valued by students. Some students in Group A remarked that they were still required to have the teacher confirm whether the AI was correct and give the larger perspective which AI was devoid of. Therefore, instead of substituting teachers, AI can supplement them - doing routine questions, whereas teachers can resort to more advanced instructions. Conclusively, the adoption of AI based on generative AI in education is a paradigm shift with a potential of promise and full of challenges. The overall effect will be determined by the reactions of the educators, students and institutions to these discoveries: by developing pedagogies that will capitalize on the strengths of AI (personalization, scalability, creativity) and contain its weaknesses (accuracy, shortcutting tendencies, ethical risks).

4. Conclusion

This paper aimed to consider the changing face of pedagogy in the context of the existing generative artificial intelligence with particular attention to what opportunities and threats the given technology brings. Our experiment in the controlled classroom with surveys and interviews provided us with empirical evidence that will help to learn the role of generative AI in education in a more nuanced way.

Summary of Findings: We discovered that when students were allowed to use a generative AI (ChatGPT) as a learning resource, performance level in coursework grew and efficiency improved, which points out the possibilities of AI to be a valuable addition to learning experiences in short-term of usage. The students supported with AI came up with better assignments, were able to receive on-demand clarifications and feedback, and said they felt less pressured by the (perceived) workload. These findings confirm the hopeful perspective that generative AI can become a potent personalized tutor and helper, which is consistent with the other reports that the AI can facilitate learning and teaching activities, namely, the design of learning material, delivery of feedback, and other creative issues solutions. But our findings also showed that, concerning a closed-book exam, in which they were denied AI, the same students scored significantly worse on the average than did their AI-free learning counterparts. This implies that relying on AI resulted in a less profound learning or the memorisation of knowledge, in our experimental context, the AI group knew the material better than the control group, even though they performed better in the assignment. Essentially, the AI enhanced productivity but at least it appeared at the cost of internalized knowledge. This reading was supported by self-reports by students: many of them acknowledged getting addicted to AI and possibly spending less time on in-depth reading of the material, which repeats the argument that generative AI can promote procrastination and short-cuts that can drain performance.

Moreover, the research shedding light on the student perspective on the opportunities and challenges, the research shedding light on the attitude of students to the work process. On the one hand, students recognized that generative AI made life more convenient and offered them personal assistance, and tends to describe it as having a tutor on call to answer any questions or elaborate on their points. They also reported a better feeling of confidence to complete assignments and to explore subjects (some of the subjects went beyond the curriculum due to examples provided by AI or more advanced questions). Negatively speaking, such concerns as the inaccuracies of the AI that happens occasionally (and have to be thoroughly fact-checked) and the ethical ambiguity of the application of AI to academic work were highly indicative among the students. Students were also torn between the options of whether they were engaging in real learning or cheating even in cases where they were allowed to use AI. They also raised the issue with privacy and how one should be guided to use it. These sentiments can be seen to reflect a microcosm of the larger educational discourse: admiration of the potential of AI in helping with tutoring on the one hand, and, on the other hand, fear of academic dishonesty, and the moral implications of AI in education.

The article makes new contributions of both empirical data and knowledge in a field that, recently, was dominated by speculation and theoretical debates. Specifically, it provides: Objective data on how AI influences learning performance: Our controlled study measures the increase in the benefit (greater assignment grades, +5 percentage points on average) and the cost (-4 points on exams, on average) of AI-based support in an individual learning environment. Such data contribute towards shifting the discussion away away more towards anecdote to analysis to educators and policymakers by informing them on what kind of impacts they should expect in case AI is applied in coursework. A description of the student experience and attitudes in detail: We put record of what students found useful and problematic so as to provide guidance on how to meet the needs and concerns of pedagogical techniques to the learners. As an example, students are willing to learn how to check the policy of using AI and how to train to identify the outputs of AI, things that would be practical on the part of the institutions. Commendation of crucial variables to successful integration: According to our results, we claim that any successful integration of generative AI in education should comprise (a) redesigned assessments that achieve authentic learning and discourage AI-paid-off cheating, (b) AI literacy training of students (and faculty) to educate them to critical use of the tools, and (c) ethical guidelines and ethics support (through honor code to potentially technical means) so as to foster AI to learn with Generative AI as opposed to to learn with the student. These aspects are significant to us because, due to available data, we could observe how the conventional examination revealed the weaknesses of AI-contingent education, and how existing knowledge was necessary as students had to discover the pitfalls of AI themselves.

The fact that our study empirically corroborates theories of how generative AI may transform cognitive and social learning factors supports the growing number of studies interested in the topic. It indicates that the ideas of cognitive load, motivation, self-regulation, and metacognition should be re-evaluated in case of AI. As an example, other students have delegated self-regulation to the AI (leaving the artificial intelligence to decide how to go about a problem), which influenced their learning performance. These perspectives open the path to further studies on human-AI co-learning structures: How can we design learning activities that will best allocate learning activities between human and AI, maximizing learning? How will we make certain that the human remains have been in charge of the learning objectives and reflective thinking?

In the context of educators working at the front lines, we have implications in practice. The assessment policies must change adding more in-person or supervised assessments, project-based assessments, oral tests, where necessary, to make sure that grades are obtained based on the ability and the knowledge of the student. In case of take-home assignments, the instructors may expressly permit AI but make students record their procedure and defend their responses therefore making the learning to be visible. The curriculum development might require the introduction of the aspects of AI training, the simplest one being the ways in which one can be effective in prompts and, more importantly, how to notice, when AI is going astray, and the most complex one might be the ethics and social issues of AI (digital literacy and critical thinking, which are the most vital skills of the 21 st century). Institutions should also think about the possibility to provide infrastructure - vetted AI tools, which are safe and need in education (some universities are testing the implementation of custom AI mentors, which are limited only with correct course-related information).

As policy, universities and schools can gain positively by considering institutional policies on AI that are not too liberal and yet very restrictive. We found that students were capable of respecting and obeying definite rules, however, uncertainty will result in disrespect or fear. As such, the policies may say that one can rely on generative AI into certain learning tasks (under the knowledge of a teacher), but the final submissions will be the work of the student, with the contribution of AI to it properly credited. It is also possible that they specify the consequences in case of misuse, similar to the plagiarism policies, however adjusted to AI. The cooperation between educators is also of essential importance: best practices (such as the ability to write assignment prompts that are AIs resistant or creative methods of integrating AI into classroom activity) should be shared between educators, which will speed up the collective pedagogy.

It should be noted that there are limitations of this research. To start with, the sample size and context is rather narrow, a single course at a university, at an area of professional data science, among technically-skilled students. The dynamics may be different between different contexts (e.g. the humanities writing classes, teaching in K-12, or professional training). As an example, the AI approach to grammar could be compared to a purported disadvantage of creating an environment where students may not form their own identity, in a pure writing course. The matters of maturity and guidance would be dominant in younger groups of students. Thus, we should be careful not to generalize our numerical findings. But it is probably the overall themes (efficiency vs. integrity, improved output vs. learning depth) which are quite broad applicable. Second, our time period was 1 semester; we failed to follow-up on long-term retention and the possible possibility of students in the AI group catching up on the same. It is possible that the early superficial learning might be corrected through subsequent education (the wake-up of the examination might have served Group A a lesson against the excessive dependence on AI). Longitudinal studies would help to determine whether short-term detriments may be observed in the long term. Third, and although we tried to blind grade and isolate AI as the variable, the fact of being an AI group might have other effects of motivation or behavior. One of the ways in which we attempted to alleviate this is by making the control group obtain a rich learning experience and by ensuring that the AI did not use high stakes. However, psychological aspects may be different: maybe Group A had more faith in the AI, or Group B made more efforts because they did not have additional assistance. These are the intangible variables that are difficult to be fully manipulated and may have any impacts.

Due to the fast-evolving nature of the AI technology, research will always be needed in the future. Further research could consider many of the dimensions that have been relied upon but not thoroughly discussed in this paper. As an illustration, what impacts are generated AI on various kinds of learners? It could be good news to independent learners who are able to use it as a discovery, but a support to those who lack sufficient self-control. Developing more focused AI integration approaches through exploring personality or learning style interaction with AI use may inform AI integration. The other way is to experiment with interventions to reduce the learning demerit - such as asking a question and asking students give an answer on their own before AI gives its answer, or asking students to give the answer and then have AI give it - and assess the results of learning. Embracing of AI in collaborative learning can also be researched: when a group of students is working together and using an AI, whether it supports or obstructs peer chat and knowledge co-construction? As multimodal generative AI (such as image understanding with GPT-4) becomes available, research may focus on applications in areas such as geometry (stating diagrams) or art and design (creative co-generation). Also, we need to have sound AI literacy program assessment - in the event that we educate the students directly with how to utilize AI, is it possible to achieve a decrease in the adverse outcomes (such as decreased overreliance, improved critical use)?

Conclusively, as a futuristic outlook, one of the eventual plans of implementing AI in education is to equip the students with a world, where AI is everywhere in workplaces and in their everyday lives. In that regard, effective AI-based pedagogy must be an outcome of learning: learners must not just be equipped with the knowledge of the subject but also be prepared to learn to use AI in their field ethically and efficiently. According to our research, some of these skills can be picked up naturally by the students (they discovered the problem of accuracy, etc.), yet a more systematic one can be useful. Future success could be defined based on the abilities of a student to use AI to tackle difficult novel tasks - which is a skill combining human critical thinking with AI computing capabilities. This synergy is the big thing being able to provide to education through the generation AI. One of the respondents said that given the ability to learn how to implement AI wisely, I can work on creative concepts and leave the AI to do the low-level jobs. This is the summary of a vision in which AI becomes a complement and not a substitute of human learning.

Generative AI is neither a panacea nor a plague in education - it is an instrument, and its functioning is associated with the enhancement of human intentions and skills. They can bring a personalized support, involving students in new activities, and make the process of learning more efficient and accessible as it is demonstrated in this study. When applied carelessly, it is capable of approaching the process of learning with a short circuit and subjecting the educational evaluation to question. The role of schools and educationist can therefore play a significant role in leveling the scale to the former. Through revision of the pedagogical design, development of AI literacy, and inculcation of ethical standards, we can incorporate generative AI in a way that improves the education process without compromising academic standards and ethical values.

we have most likely stepped in the beginning of an artificial intelligence-powered reshaping of education that is just at the same scale as the entrance of the internet or personal computers in the classroom. Change brings about uncertainty, though moreover it brings innovation. With research (including ours) still illuminating and revealing productive practices, one can imagine a future in which generative AI will become a ubiquitous and relied-upon element of the pedagogy process: students collaborating with AI to solve complex problems, teachers collaborating with AI to help them understand their learning patterns, and tests which evaluate creative and critical thinking and which depend on AI tools. That vision will be achieved through continuous effort, change, and teamwork of technologists, educators, and learners. The results of the present research present a stepping rock in that direction proving the possible benefits and the pitfalls to escape. To conclude, generative AI pedagogy is an incredibly promising field when pursued with a careful strategy - it presents the possibility to optimize the current learning process, as well as gives access to a wide range of educational opportunities, albeit only to address and control these challenges actively and critically. The challenge now is that the educational community should investigate these discoveries, further test them, and build

strong systems in order that the following generation of learners will enjoy all the advantages of AI as a learning companion and not a scam.

The interaction of generative AI and pedagogy is a good field to innovate. This paper confirms that there are not only good opportunities to be used but also grand challenges to face. Through diligent methods that use AI research work, teachers can leverage the power of generative AI to empower learners, scale-based education personalisation and better equip students to learn how human-AI interaction will manifest itself in the future. Simultaneously, the educational fraternity has to be keen to preserve the three main values of learning - understanding, creativity, and integrity, so that to make sure that the values do not disappear under the spell of automation. This balance can give pedagogy on generative AI an opportunity to change the current stage, experimental studies into what will become the standard practices in the future, and eventually replenish and enhance the educational environment in the future generations as well.

Author Contributions

OAA: Conceptualization, study design, analysis, writing review and editing, and supervision. JR: Analysis, data collection, methodology, software, resources, visualization, writing original draft, writing review and editing, and supervision. MOO: Writing original draft, writing review and editing, and supervision. NLR: Data collection, methodology, software, resources, visualization, writing original draft.

Conflict of interest

The authors declare no conflicts of interest.

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