Enhancing creativity education through AI: A study of divergent thinking skills among Moroccan university students

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Abstract
Creativity is a hallmark of what makes us human, and educators worldwide dedicate their efforts to nurturing their students' cognitive development. This empirical study aims to investigate the association between generative artificial intelligence (AI) and the creative thinking of Moroccan university students as they prepare and produce educational scenarios for real classroom implementation. Artificial Intelligence has been increasingly explored as a tool that may support certain aspects of learning and creative engagement, despite the fact that its impact on measurable creativity outcomes remains debated in the literature. As scholars have identified multiple dimensions of creativity, the present research focuses on divergent thinking. The study uses a mixed-methods approach integrating quantitative and qualitative data. The Reisman Diagnostic Creativity Assessment (RDCA) serves as a self-report tool, and to assess its efficacy, a quasi-experimental design is implemented. This design employs a one-group pre-test and post-test methodology, complemented by a paired-samples t-test for statistical analysis. Participants in the experiment are Moroccan undergraduate students (n = 56) enrolled in the English Department at the École Normale Supérieure in Fez, Morocco. Additional semi-structured interviews were conducted for qualitative data collection. During teaching practice, in designated schools, students are required to develop lesson plans that incorporate potential scenarios for teaching different subjects to young learners. They often use AI tools, like ChatGPT, to generate and tailor these scenarios to meet particular requirements. Although ChatGPT has evolved through several model versions, the present study focuses specifically on GPT-4o to address the following research questions: i) What are the students' attitudes toward using GPT-4o to generate educational scenarios that can be implemented in the classroom context? ii) What is the impact of using GPT-4o on the students' divergent thinking abilities, and to what extent can it help improve students' creativity? iii) To what extent do students perceive GPT-4o as a collaborative partner in their instructional design process? Findings from this study on the use of GPT-4o revealed minor improvement trends that did not reach statistical significance, suggesting that one semester of practical teaching is insufficient to produce measurable effects. Specifically, quantitative data indicated no statistically significant differences ($p > 0.05$) across creativity-related constructs, including fluency, flexibility, originality, and elaboration. However, qualitative findings revealed that students perceived AI tools as supportive for idea generation, organization of thoughts, and confidence building.

Keywords: *artificial intelligence, creativity, divergent thinking, teaching English, students.*

Introduction

For human beings, creativity is an essential determinant when accessing personal, academic, and professional development. In any given situation of their existence, individuals contribute meaningfully to society by innovating or collaborating to solve complex problems. In a specific context like education, fostering creativity is considered crucial when preparing future generations to navigate an increasingly complex and dynamic world. The significant importance of creativity in education lies not only in its direct

benefits for individual learners but also in its broader societal value, driving cultural and technological advancement. Ultimately, emerging pedagogical frameworks position nurturing creativity as a core objective, alongside traditional knowledge acquisition. This approach ensures that students develop essential skills for lifelong learning and adaptability (Li et al., 2025).

Among the various dimensions of creativity, divergent thinking holds a central position due to its emphasis on generating multiple, diverse, and novel ideas rather than converging on a single correct answer. Divergent thinking encompasses skills such as fluency (the ability to produce numerous ideas), flexibility (the capability to produce a variety of ideas across different categories), originality (idea novelty), and elaboration (the detail and development of ideas). The combination of these skills forms a crucial aspect of what Baltà-Salvador et al. (2025) refers to as creative cognition, empowering learners to tackle problems with a more open and innovative mindset. In today's fast-paced world, teachers play a vital role in fostering students' capacities and equipping them with the tools needed to enhance creative thinking across various learning contexts. With the rapid evolution of educational technologies, artificial intelligence tools—particularly large language models like GPT-4o—offer remarkable opportunities to boost creative thinking and support teachers in their instructional methods (Akhmadieva et al., 2024). GPT-4o is a ground-breaking technology that effectively generates coherent and contextually relevant text across various domains. Its capabilities extend to crafting instructional scenarios for classroom implementation, proposing lesson plans, and delivering personalized feedback. This makes GPT-4o an invaluable asset in education, particularly in enhancing creativity and fostering divergent thinking among students (Abdul Kadir & Rusyda, 2022; Coelho, 2024).

In this context, the current study investigates GPT-4o within the broader landscape of educational technologies that leverage AI to enhance learning and teaching experiences. It uses a mixed-methods approach with a quasi-experimental research design that targets Moroccan undergraduate students (n=56) from École Normale Supérieure in Fez. The Reisman Diagnostic Creativity Assessment (RDCA) serves to collect quantitative data, while qualitative data is collected by means of semi-structured interviews (Reisman et al., 2016). Importantly, this research does not aim to establish causal relationships between AI use and creativity outcomes. Rather, it adopts an exploratory perspective, examining students' self-reported creativity and perceptions following exposure to AI-supported activities.

Theoretical background on divergent thinking and creativity

In recent years, technology has taken on a pivotal role in nurturing creativity and encouraging divergent thinking. Artificial Intelligence, especially through intelligent assistants and generative models like GPT-4o, has shown remarkable promise in personalizing learning experiences, spurring ideation, and supporting the creative process. These AI tools can generate creative prompts, offer fresh perspectives, and help learners navigate various problem-solving approaches, ultimately boosting cognitive flexibility and originality (Baltà-Salvador et al., 2025). Additional digital tools, such as multimodal creative software and AI-powered content generators, can further enhance the manipulation of intricate creative thinking processes. This, in turn, empowers students to generate and elaborate on their ideas more effectively (Albakry et al., 2025).

Rooted in creativity research, divergent thinking refers to the cognitive process underlying the generation of multiple unique ideas or solutions to open-ended problems (Rawlings et al., 2025). Divergent thinking stands in contrast to convergent thinking, which tends to be linear and aims at identifying a single correct answer. Evaluating divergent thinking involves examining specific one ideas come from), originality (the uniqueness or rarity of the ideas), and elaboration (the level of detail added to each idea) (Xiang, 2024). These aspects highlight the importance of creative output within educational environments.

The Reisman Diagnostic Creativity Assessment (RDCA) is a robust self-report instrument explicitly designed to capture essential dimensions of creativity. It empowers learners to reflect deeply on their

creative behaviours and thought processes. This test effectively measures ten crucial constructs related to creativity: fluency, flexibility, originality, elaboration, tolerance of ambiguity, risk-taking, intrinsic motivation, extrinsic motivation, decision-making, and metacognitive awareness (Reisman et al., 2016). These tools are essential as they deliver both quantitative data for rigorous analysis and qualitative insights into students' self-perception of creativity. Their value in mixed methods research frameworks is undeniable (Baidoo-Anu & Owusu Ansah, 2023) Divergent thinking encompasses essential cognitive and metacognitive aspects that demand not only the generation of ideas but also critical reflection, evaluation, and iterative improvement. These processes are crucial for cultivating creativity in learners (Khotimah et al., 2024).

Nevertheless, as AI is continuously acquiring new capabilities, major challenges have emerged that require careful consideration. Khatri & Karki (2023) suggest that ethical and responsible use of AI tools must underpin pedagogical applications to mitigate risks related to privacy, bias, and academic integrity. The main growing risk fosters overreliance and results in potentially diminishing students' independent critical thinking and creative autonomy (Holmes & Porayska-Pomsta, 2022). In other words, AI-generated outputs may stifle originality or promote formulaic responses if not integrated within robust pedagogical frameworks that emphasize human agency and reflection.

Effective pedagogical integration of AI requires a clear theoretical and instructional grounding in theoretical frameworks that foster meaningful learning and engage students. From a sociocultural standpoint, knowledge construction is viewed as a mediated process, influenced by the use of semiotic tools and contextual interactions (John-Steiner & Mahn, 1996). At the same time, self-determination theory (SDT) offers valuable insights into the motivational aspects of learning, highlighting the necessity of autonomy, competence, and connection in maintaining engagement and encouraging creative efforts (Xiang, 2024). Within this theoretical context, it is essential to differentiate between creativity as a broad, multidimensional concept and divergent thinking, which serves as one of its measurable cognitive elements. For this study, we operationalize creativity through divergent thinking, evaluated using the RDCA dimensions of fluency, flexibility, originality, and elaboration. This distinction clarifies the connection between AI-supported performance, self-reported creativity, and the actual outcomes of measured divergent thinking, which may not progress at the same rate. In this framework, AI—especially GPT-4o—is viewed not as a direct source of creativity but rather as a supportive cognitive tool that can help generate ideas, provide structure, and encourage reflective thinking in instructional design tasks. Thus, instructional design (or lesson planning) becomes the practical context where AI-enhanced cognitive processes can impact the students' perceived imaginative abilities and their actual creative performance.

AI technologies and their creative capabilities

Generative AI and Large Language Models (LLMs)

What has traditionally required human expertise is now easily handled by large language models (LLMs) that are capable of generating original content, reinterpreting ideas, and assessing creative outputs. Existing models are trained on extensive textual datasets and possess a built-in automated capability of enhancement in creative tasks, along with the ability to generate psychometric creative assessment items (Zhao et al., 2025). Therefore, existing computational models offer formalised representations of creative processes, simulating various aspects of creativity within artificial systems. Building on established typologies, Boden (2009) identifies three distinct types of creativity modelled by AI. The first, combinational creativity, involves algorithms that blend existing knowledge to generate new outputs. The second type, exploratory creativity, refers to the process where algorithms navigate through predefined conceptual spaces. Lastly, transformational creativity is characterized by the modification or expansion of these conceptual spaces.

As humans engage more with AI-generated content, recent research underscores the undeniable potential of AI to serve not just as automated creators, but as powerful co-creation partners that

significantly enhance human creativity (German et al., 2019). Frameworks like the human-AI co-creative segment model clearly outline how AI and human designers interact. As highlighted by Wu et al. (2021), these models pinpoint specific modes of interaction and cognitive behaviours that facilitate dynamic and iterative co-creation. They emphasize the active role of human agency in effectively leveraging AI's generative capabilities. Collaborations between AI systems and human designers exemplify co-evolution, where both parties adapt and evolve their practices in direct response to each other.

GPT-4o as a tool for generating educational scenarios

In classroom settings, AI-generated content is making a significant impact. It excels in areas like language teaching, STEM education, and creative design activities that demand ideation and reflection. Leveraging advanced natural language processing capabilities, GPT-4o can generate educational scenarios that produce diverse and contextually relevant content aligned with specific instructional objectives. These applications undoubtedly enhance learner engagement by delivering varied and dynamic learning experiences, fostering active participation, and promoting deeper cognitive involvement (Acosta-Enriquez et al., 2024). The integration of these scenarios is essential for fostering collaborative learning. It empowers students to collectively explore AI-generated content and engage in meaningful discussions. This dynamic process not only promotes social interaction but also enhances collective creativity (Baltà-Salvador et al., 2025). This suggests that GPT-4o may serve as an essential resource for lesson planning and fostering creativity in teaching. It provides powerful suggestions that can inspire educators and enhance traditional curricula (Elkhodr et al., 2023). The tool's versatility empowers educators and students to craft scenarios across a wide range of subject domains, effectively meeting diverse pedagogical objectives. It is designed to enhance critical thinking, encourage collaboration, and simulate real-world problem-solving with precision (Ködding et al., 2023).

While the benefits of AI-generated educational scenarios are significant, it is imperative to recognize their inherent limitations and challenges. These scenarios often fall short, being too generic, culturally biased, or inaccurate, which can lead to misunderstandings and perpetuate stereotypes when applied uncritically. AI excels at reproducing and recombining learned patterns, but it lacks the intentionality and flexible, self-driven evaluation that defines human creativity. This stark contrast underscores the urgent need for human oversight and the development of hybrid models to elevate the creative process (Cox et al., 2023). It is crucial for educators to carefully assess and contextualize AI-generated content to ensure it remains relevant and appropriate. Additionally, ethical concerns arise regarding our reliance on AI, as it can hinder creativity and raise issues surrounding academic integrity. This calls for transparent policies and teaching strategies that maintain a balance between the use of AI and the necessary human oversight (Coelho, 2024; Holmes & Porayska-Pomsta, 2022; Akhmadieva et al., 2024).

Context of the study

In Morocco, the École Normale Supérieure (ENS) serves as a prominent higher education institution and teacher training college dedicated to preparing future educators for careers in both public and private education sectors. With campuses located in several major cities, ENS offers a variety of specialized academic and pedagogical programs tailored for a broad spectrum of subjects, including Mathematics, Sciences, Arabic, French, Philosophy, and English, equipping aspiring teachers with the necessary skills and knowledge to excel in their fields.

The English Department at ENS is dedicated to preparing English as a Foreign Language (EFL) teachers by equipping them with essential skills in language proficiency, instructional design, classroom management, and educational technology. After undergoing a thorough selection process, students follow a well-structured curriculum that blends theoretical knowledge with hands-on teaching experience, including required internships at local schools. Through its comprehensive programs, ENS

plays a vital role in shaping the future of education in Morocco, ensuring that teaching methods align not only with national curriculum standards but also adapt to the evolving needs of today's classrooms.

This study was carried out with undergraduate university students enrolled in the English Department at the École Normale Supérieure (ENS) in Fez, Morocco. These students are part of a professional teacher-training program designed to prepare them for careers in primary and secondary education. In addition to their core coursework in English, which covers areas such as linguistics, literature, and pedagogy, they participate in a mandatory weekly teaching internship. During the initial stage of the internship, students primarily engage in administrative and technical support roles, including managing classrooms and assisting with logistics. However, as they gain more experience, they gradually take on more pedagogical responsibilities, specifically focusing on remedial teaching for students who face learning difficulties.

To execute the teaching assignments, student interns are required to come equipped with their lesson plans that detail learning objectives, teaching procedures, and creative activities aimed at engaging and supporting their target learners. This process requires an impressive capacity for creativity and divergent thinking, especially when it comes to adapting lessons for students with learning difficulties (Baltà-Salvador et al., 2025; Khotimah et al., 2024).

Gradually, many students started seeking suggestions from GPT-4o and incorporated them in their lesson planning processes. Drawing on its ability to generate ideas for content delivery, students used the AI tool as a form of pedagogical assistant, providing classroom activities. AI-supported interactions are essential tools that significantly expand instructional possibilities and enhance creative teaching methods for students. Research consistently demonstrates that users hold a positive perception of GPT-4o, emphasizing its user-friendly interface, engaging features, and capacity to deliver personalized learning support effectively (Akhmadieva et al., 2024; Elkhodr et al., 2023; Wu et al., 2021). Many students clearly recognize the tool's ability to deliver customized educational content and foster active engagement, significantly boosting motivation and satisfaction in their learning experiences (Acosta-Enriquez et al., 2024). The growing incorporation of generative AI in teacher preparation presents a crucial opportunity to examine the impact of GPT-4o on students' creative development, particularly in the areas of fluency, flexibility, originality, and elaboration (Abdul Kadir & Rusyda, 2022; Reisman et al., 2016).

Research methodology

The present study is definitively structured to investigate the pedagogical implications of integrating generative AI—specifically GPT-4o—into the instructional design practices of Moroccan undergraduate students pursuing English language teaching. Utilizing a rigorous convergent mixed-methods design, this research combines both quantitative and qualitative data collection techniques to deliver a comprehensive analysis of the effects of GPT-4o on the creativity and instructional planning practices of Moroccan university students (Flick, 2018). Central to the design is a quasi-experimental framework that utilizes a one-group pre-test/post-test method without a control group for quantitative data, as undergraduate students at ENS-Fez represent a singular cohort during the spring of 2025. This allows the researcher to measure changes in students' creativity over time, as a follow-up to a GPT-4o-supported AI-supported pedagogical integration that lasted twelve weeks and was embedded within a regular course module of lesson planning. Students took part in one AI-supported activity per week, each lasting approximately 60–90 minutes. Activities included brainstorming essay topics, generating alternative viewpoints, refining arguments, and reflecting on drafts using a generative AI tool. Students were encouraged to use GPT-4o as a supportive tool rather than a content replacement, with the instructor emphasizing critical evaluation, originality, and academic integrity. The instructor guided students on prompt formulation, reflection, and ethical use of AI outputs. It should be noted that while quantitative analysis provides insights into trends, the study does not claim statistically significant effects due to the limited sample size.

With regard to qualitative data, nine semi-structured interviews were conducted to gain more insight from participants about the overall experience feedback of using GPT-4o to generate educational scenarios. The study seeks to address three guiding questions: (i) What are the students' attitudes toward using GPT-4o to generate educational scenarios that can be implemented in the classroom context? (ii) What is the impact of using GPT-4o on the students' divergent thinking abilities, and to what extent can it help improve their overall creativity? (iii) To what extent do students perceive GPT-4o as a collaborative partner in their instructional design process? In this study, creativity is explored through the lens of divergent thinking, which encompasses four key dimensions: fluency, flexibility, originality, and elaboration. The analysis aims to identify whether there are statistically significant differences between pre-test and post-test scores in these areas after participants take part in AI-supported instructional activities. Rather than establishing causal relationships, the study design focuses on uncovering patterns of change that emerge from the data.

The researcher relied on convenience sampling techniques to reach a group of participants that consisted of 56 students from the English department at ENS-Fez. While this limits broader generalizability, it enhances the study's ecological validity by reflecting real classroom dynamics. To assess students' attitudes and usage behaviours toward AI in instructional design, participants voluntarily provide answers to a custom survey instrument in total respect of ethical guidelines regarding informed consent and anonymity. It included demographic information along with the Reisman Diagnostic Creativity Assessment (RDCA), which measures ten creativity-related constructs (fluency, flexibility, originality, elaboration, tolerance of ambiguity, risk-taking, intrinsic motivation, extrinsic motivation, decision-making, and metacognitive awareness). Data were collected to evaluate students' engagement levels with AI-supported instructional activities across various lesson planning tasks (e.g., setting objectives, designing activities, managing the classroom, implementing assessment), using a 5-point Likert scale. The survey has been administered both before and following engagement with AI-supported activities, enabling the researcher to conduct paired-samples t-tests and compare mean scores.

To gain further depth and validity of the findings, quantitative measures were complemented with qualitative data to enrich interpretation, given the small sample and lack of statistical significance. In this respect, nine semi-structured interviews were conducted with a purposive subset of students to explore their lived experiences, perceptions of AI use, and reflections on creativity. Qualitative data were analysed using a thematic analysis approach following Braun and Clarke's (2006) framework. The interview transcripts were initially coded inductively to uncover recurring patterns related to students' views on AI usage, creativity, and instructional design. These codes were subsequently organized into broader themes. The adopted interview guide helped detect nuanced insights into how students perceived GPT-4o as a cognitive partner and resource for lesson planning. Participants were anonymized through the use of coded identifiers (S1–S9), with the number in parentheses indicating each participant's age (e.g., S2 (19) refers to Participant 2, aged 19). To enhance the trustworthiness of the analysis, a process of iterative coding and constant comparison was implemented, with representative excerpts chosen to exemplify each theme. Although the interview sample size (n = 9) limits the generalizability of the findings, it offers significant analytical depth. The study did not utilize inter-coder reliability; consequently, the results should be regarded as interpretive rather than fully generalizable.

Ultimately, a triangulation of methods—employing quantitative metrics, survey-based instructional usage data, and qualitative interviews contributed to a more comprehensive understanding of the AI-supported pedagogical integration's effects, although it does not compensate for the absence of a control group.

Reliability test

To ensure that our research instrument accurately measures students' creativity and divergent thinking, we rigorously assessed Cronbach's Alpha across ten critical dimensions: fluency, flexibility,

originality, elaboration, tolerance of ambiguity, risk-taking, intrinsic motivation, extrinsic motivation, decision-making, and metacognitive awareness. The results demonstrate strong internal consistency for both the pre-test and post-test. The pre-test achieved a Cronbach's alpha of 0.820, confirming its reliability and the effectiveness of the items in measuring the intended constructs before the integration of AI-supported pedagogical material. Following this exposure to AI tools, the post-test reliability further improved, culminating in a Cronbach's alpha of 0.862. This outcome not only confirms the instrument's robust internal consistency but also highlights its enhancement. Based on George and Mallery's (2003) guidelines, values above 0.8 indicate good reliability, suggesting that the items within each test consistently measured the intended constructs. The increase in reliability from pre- to post-test may reflect a clearer understanding or more consistent engagement with the measured domains after the introduction of AI-pedagogical tools. These results confirm that the instrument demonstrated strong internal coherence across both measurement phases, reinforcing the dependability of the collected data for further statistical analysis.

Table 1: Reliability statistics pre-test/post-test

	Cronbach's Alpha	N of items
Pre-test reliability statistics	.820	10
Post-test reliability statistics	.862	10

Normality test

To verify the assumption of normality for conducting parametric tests, skewness and kurtosis statistics were analysed for both pre- and post-test scores (Table 2). Z-scores were calculated by dividing each value by its corresponding standard error. For the pre-test data, the skewness ($z = –0.472 / 0.319 ≈ –1.48$) $z = –1.48$ and kurtosis ($z = –0.540 / 0.628 ≈ –0.86$) $z = –0.86$; while for the post-test data, skewness ($z = –0.037 / 0.319 ≈ –0.12$) $z = –0.12$ and kurtosis ($z = –0.599 / 0.628 ≈ –0.95$) $z = –0.95$. All values fall within the conventional threshold of ±1.96, indicating no significant deviation from normality. These results suggest that both pre- and post-test distributions approximate a normal curve, justifying the use of paired-samples t-tests in subsequent analysis. This approach adheres to best practices in social science research, ensuring robust statistical validity.

Table 2: Normality test

Dataset	Skewness	Std. error	Kurtosis	Std. error
Pre-test data	-0.472	0.319	-0.540	0.628
Post-test_data	-0.037	0.319	-0.599	0.628

Results

The sample for this study consists of 56 participants (Table 3), all of whom provided complete responses for the demographic variables of gender and age. Data collected shows that approximately 27% are males, while 73% are females. The mean gender score is 1.73 (SD = 0.447), which also shows that the majority of participants were females. This distribution aligns with broader trends observed in teacher education programs where female enrolment typically surpasses that of males (UNESCO, 2023).

Table 3: Gender frequencies

		Frequency	Percent	Valid percent	Cumulative percent
Valid	1	15	26.8	26.8	26.8
	2	41	73.2	73.2	100.0
	Total	56	100.0	100.0	

Regarding age (Table 4*)*, the data collected shows that the majority of respondents are 18 years old (64%), followed by 19-year-olds (27%), and a smaller group aged 20 (9%). The sample is visibly skewed toward the younger end of this age range, as the mean value of ages has a score of 18.45 (SD = 0.658). Such a narrow age range indicates a fairly uniform group of undergraduate students, which is characteristic of pre-service teacher training programs. Their developmental stage likely means they are still forming professional identities and are more open to experimenting with new technologies such as AI. However, it may also mean they require more structured guidance in critical thinking and self-regulation, which reinforces the importance of explicitly teaching AI literacy and creative design thinking in the curriculum.

Table 4: Age frequencies

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	18	36	64.3	64.3	64.3
	19	15	26.8	26.8	91.1
	20	5	8.9	8.9	100.0
	Total	56	100.0	100.0	

This demographic overview (Table 5) provides descriptive information on the gender distribution of participants and indicates that the study took place in a vibrant, predominantly female educational setting. Ultimately, this context provides a promising foundation for the early introduction of AI-supported pedagogical tools and the use of technology to enhance instruction.

Table 5: Descriptive statistics age & gender

	N	Minimum	Maximum	Mean	Std. deviation
1- Gender	56	1	2	1.73	.447
Age	56	18	20	18.45	.658
Valid N (listwise)	56				

The responses regarding students' use of AI tools to develop engaging activities (Figure 1*)* and select adequate instructional strategies (Figure 2) reflect moderate but uneven adoption across the sample. In the case of developing engaging activities, 41.1% of students selected “sometimes,” indicating a moderate level of integration. Meanwhile, 19.6% reported using AI “often” and only 5.4% chose “always.” On the lower end of the spectrum, 17.9% of participants indicated that they “never” use AI for this purpose, while 16.1% reported using it “rarely.” This suggests that although the majority are exploring AI in planning activities, a significant portion remains hesitant or disengaged.

The use of AI tools to select appropriate instructional strategies shows a clear trend among respondents. The largest group, comprising 33.9%, stated that they use AI “sometimes.” This is followed by 26.8% who indicate “rarely,” and 30.4% reporting “never.” It is evident that over half of the respondents seldom utilize AI to inform their strategic pedagogical choices. Only 8.9% reported using AI “often,” and notably, no students indicated that they “always” rely on AI for this purpose.

The findings clearly demonstrate that while some students recognize the value of AI in enhancing creativity and improving teaching effectiveness, its consistent use is still lacking. Research examining the impact of GPT-4o on divergent thinking and creative output underscores this point. AI is often perceived as an additional resource rather than a vital component of lesson planning. Consequently, improvements in creative performance are most pronounced among students who utilize AI more frequently. These trends highlight the urgent need for training programs that instill confidence and proficiency in using AI, which can enhance both student engagement and the quality of instructional planning.

Figure 1: AI tools to develop engaging activities

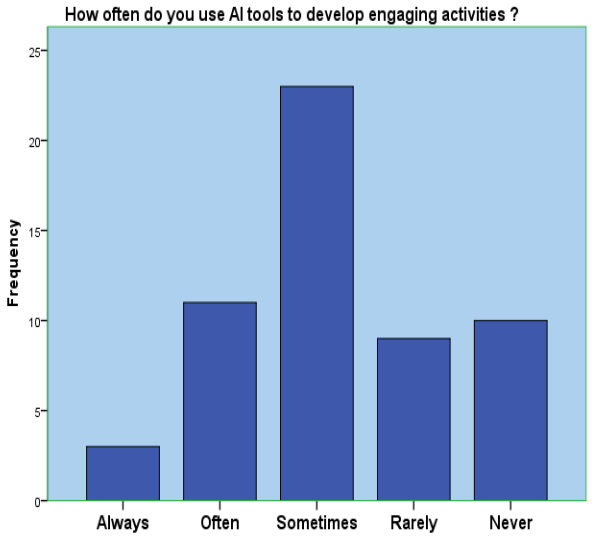
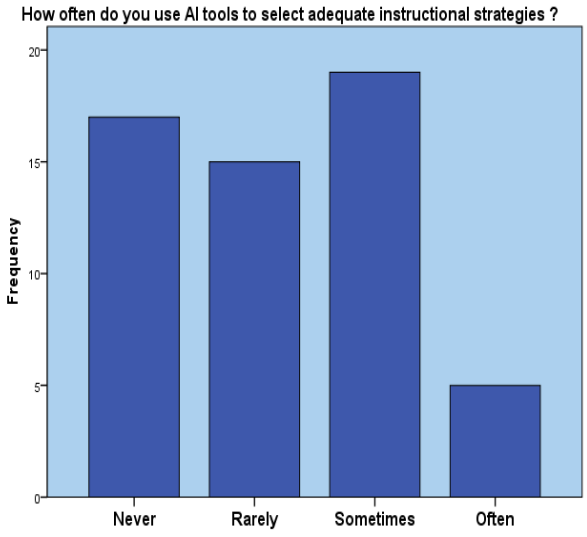


Figure 2: AI tools to select adequate instructional strategies



When asked about their use of AI tools to prepare teaching materials (Figure 3), responses varied across the frequency scale, with the majority of participants falling within the mid-to-low usage categories. Specifically, 32.1% (n=18) of students indicated they *never* use AI tools for this task, while 14.3% (n=8) reported doing so *rarely*. Another 30.4% (n=17) of students claimed to *sometimes* use AI for material preparation, showing a moderate level of engagement. Only 19.6% (n=11) said they *often* used AI in this way, and a mere 3.6% (n=2) *always* utilized AI tools. These numbers suggest a relatively cautious adoption of AI for preparing instructional content, with a strong lean toward minimal or occasional use. The relatively low engagement might reflect a lack of familiarity with the tools' capabilities, concerns over accuracy or relevance, or a continued preference for traditional methods. For a study focused on creativity and lesson design, these figures indicate that while students are exploring AI, they may still require more structured guidance or confidence to integrate these tools into core preparation tasks.

Regarding the use of AI tools to plan for multiple learning paces (Figure 4), the pattern is similar. 32.1% (n=18) of students said they *never* use AI for differentiated pacing strategies, while 25% (n=14) do so *rarely*. 26.8% (n=15) reported they *sometimes* apply AI in this context, and 12.5% (n=7) *often* do. Again, only 3.6% (n=2) reported *always* using AI to tailor lesson pacing. This trend points to a general underutilization of AI for accommodating student diversity in learning speeds and needs. In the context of instructional design and inclusive education, this represents a key area where students might not yet be fully leveraging AI's adaptive and assistive potential. Given that pacing is critical to managing classroom dynamics and supporting both struggling and advanced learners, these findings highlight the importance

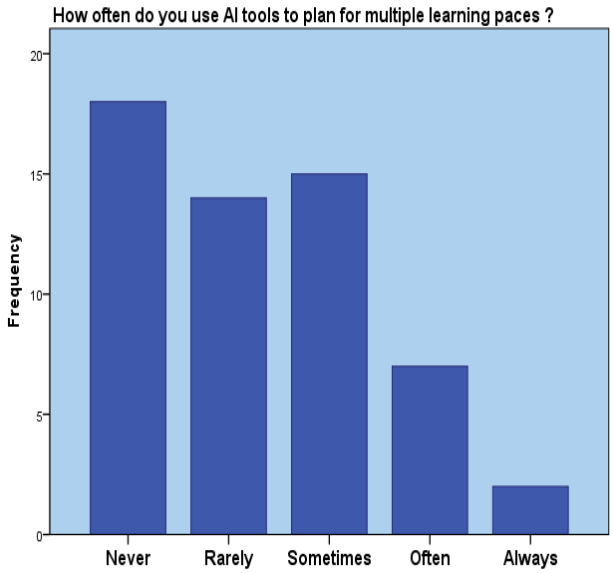
of training students not just in how to use AI, but in how to apply it meaningfully for differentiated instruction.

These insights highlight that, while ENS Fez students are becoming increasingly aware of and experimenting with AI in lesson planning, there is still limited integration, particularly when it comes to personalized pedagogy and material preparation. This points to a notable gap between the technological opportunities that AI presents and the teaching practices that students currently adopt. The AI-supported pedagogical integration and creativity-focused instructional training outlined in this study aims to bridge this gap.

Figure 3: AI tools to prepare your teaching materials



Figure 4: AI tools to plan for multiple learning paces



Based on the analysis of the frequency and descriptive statistics (Table 6), several patterns emerge regarding students' use of AI tools in lesson planning. The task with the highest reported usage is “Practicing lessons” (M = 2.98, SD = 1.213), followed closely by “Setting specific objectives” (M = 2.80, SD = 1.197) and “Developing engaging activities” (M = 2.79, SD = 1.124). These results suggest that students find AI tools particularly useful in supporting the instructional flow and creative engagement aspects of teaching preparation.

In contrast, the least utilized AI-supported task is “Seeking students’ feedback” (M = 2.18, SD = 1.223), indicating a possible hesitation or lack of awareness in using AI for reflective or formative assessment practices. This aligns with the frequency table, where 42.9% of respondents reported “never” using AI for this task. Other tasks with similarly low mean scores include “Selecting adequate instructional strategies” (M = 2.21), “Planning for multiple learning paces” (M = 2.30), and “Anticipating potential challenges” (M = 2.36), suggesting that higher-order instructional design tasks are less frequently supported with AI tools.

The frequency data also shows that most students “sometimes” use AI tools for foundational tasks like “Studying curriculum guidelines” (48.2%) and “Setting objectives” (46.4%), with only a small proportion reporting “often” or “always” usage across any category. This points to an emerging but still moderate level of AI integration in pedagogical planning among ENS students.

Overall, the findings suggest that while AI is beginning to be integrated into certain planning aspects—especially those involving idea generation and structuring lessons—it is less commonly applied to reflective practices or differentiated instruction. This underscores the need for further training and support to help future teachers leverage AI more broadly and effectively across all stages of lesson planning.

Table 6: AI frequency descriptive statistics

How often do you use AI tools to	N	Mean	Std. deviation
Study the curriculum guidelines	56	2.52	.972
Set specific objectives for the lesson	56	2.80	1.197
Assess the students' need	56	2.57	1.373
Select lesson topics	56	2.71	1.398
Plan the structure of the lesson	56	2.68	1.162
Develop engaging activities	56	2.79	1.124
Select adequate instructional strategies	56	2.21	.986
Prepare your teaching materials	56	2.48	1.236
Design assessments	56	2.41	1.218
Plan for multiple learning paces	56	2.30	1.159
Integrate technology	56	2.70	1.235
Practice your lessons	56	2.98	1.213
Plan your classroom management	56	2.39	1.231
Anticipate potential challenges	56	2.36	1.182
Seek students' feedback	56	2.18	1.223
Draw self-assessment elements	56	2.37	1.259
Valid N (listwise)	56		

The pre-test descriptive statistics (Table 7) offer a valuable baseline of students' cognitive and creative capacities before their exposure to AI tools for lesson planning. Overall, the data reveal relatively high mean scores across all ten measured domains, suggesting that participants already possessed moderately strong skills in divergent thinking, motivation, and decision-making. Notably, the highest mean was observed in Extrinsic Motivation (M = 5.21), followed closely by Meta-Cognitive Skills (M = 4.98), Flexibility (M = 4.96), Intrinsic Motivation (M = 4.83), and Decision-Making (M = 4.83). These results indicate a group that is already reflective, self-motivated, and responsive to external rewards—traits that support effective teaching and creativity.

Conversely, the lowest scores were recorded in Tolerance for Ambiguity (M = 4.17) and Risk-Taking (M = 4.63), suggesting some hesitation among students to embrace uncertainty or take creative risks, which are essential for innovation in education. Nevertheless, these scores remain above the midpoint, indicating a generally positive disposition. The standard deviations, ranging from approximately 0.62 to 0.86, reflect moderate variability in student responses. This pre-test profile sets a strong foundation for analysing post-test results and helps interpret the potential effects—whether modest or significant—of integrating AI tools into teacher training programs.

The post-test descriptive statistics (Table 8) reflect the students' self-perceived cognitive and creative thinking abilities after using AI tools for lesson planning. The mean scores across most domains remain relatively high, indicating that the participants continued to demonstrate strength in various components of divergent thinking and cognitive engagement. Decision-Making recorded the highest mean (M = 4.99),

closely followed by Meta-Cognitive Skills (M = 4.88), Fluency (M = 4.81), Intrinsic Motivation (M = 4.79), and Flexibility (M = 4.90). These results suggest a consistent ability among students to think reflectively, generate ideas, and adapt their thinking—key traits in creative lesson planning.

Table 7: Pre-test descriptive statistics

	N	Minimum	Maximum	Mean	Std. deviation
Pre_Fluency	56	3.33	6.00	4.7577	.64637
Pre_Flexibility	56	3.40	6.00	4.9607	.61900
Pre_Originality	56	2.50	6.00	4.6810	.63494
Pre_Elaboration	56	2.75	6.00	4.7634	.65612
Pre_Tolerance	56	2.50	6.00	4.1652	.82610
Pre_Risk_Taking	56	2.67	6.00	4.6310	.85677
Pre_Intrinsi_Motivation	56	1.75	6.00	4.8348	.72657
Pre_Extrinsic_Motivation	56	3.00	6.00	5.2083	.79025
Pre_Decision_Making	56	2.50	6.00	4.8304	.76739
Pre_Meta_Cognitive	56	3.00	6.00	4.9821	.71962
Valid N (listwise)	56				

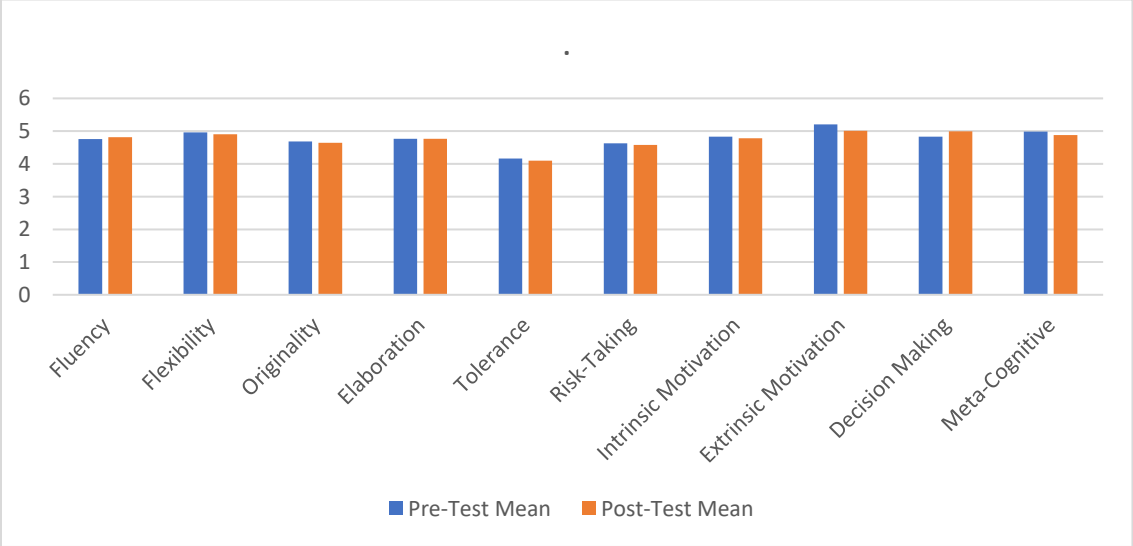
The lowest scores were again observed in Tolerance for Ambiguity (M = 4.10) and Risk-Taking (M = 4.58), mirroring trends from the pre-test and indicating ongoing challenges in embracing uncertainty and taking bold pedagogical steps. Extrinsic Motivation slightly declined (M = 5.01) yet remained strong, reflecting students' responsiveness to external incentives. The standard deviations, ranging from approximately 0.54 to 0.97, reveal moderate variability, with Meta-Cognitive Skills showing the greatest spread, perhaps reflecting differing levels of experience or comfort with reflective thinking post usage of AI. Overall, the post-test data suggest a stable profile, with only minor shifts, reinforcing the earlier interpretation that short-term exposure to AI tools had minimal impact on the measured creative capacities.

Table 8: Post-test descriptive statistics

	N	Minimum	Maximum	Mean	Std. deviation
Post_Fluency	56	3.33	5.83	4.8125	.54593
Post_Flexibility	56	3.40	6.00	4.9036	.68542
Post_Originality	56	3.00	6.00	4.6399	.65964
Post_Elaboration	56	2.75	6.00	4.7634	.67153
Post_Tolerance	56	1.50	6.00	4.0982	.80999
Post_Risk_Taking	56	2.00	6.00	4.5774	.88418
Post_Intrinsic	56	2.50	6.00	4.7857	.71260
Post_Extrinsic	56	3.00	6.00	5.0119	.86214
Post_Decision_Making	56	3.50	6.00	4.9911	.76123
Post_Meta_Cognitive	56	2.50	6.00	4.8839	.97230
Valid N (listwise)	56				

The mean differences across most variables are quite small, suggesting a general stability in divergent thinking traits after the AI-based pedagogical integration (Figure 5). The largest numerical variation can be seen in Decision Making, which increased by +0.1607, indicating that students might have gained greater confidence or developed a more structured approach after using AI tools. On the other hand, the largest decrease is noted in Extrinsic Motivation, which dipped by −0.1964. This could point to a shift away from motivation driven by external rewards, leaning instead towards a more intrinsic or curiosity-based drive. Elaboration showed no change at all, indicating that the AI-based pedagogical integration had no measurable impact in this area. Furthermore, the standard deviations remained consistent between the pre- and post-tests, reinforcing the idea that response patterns were stable and that the usage of AI did not result in any significant variations.

Figure 5: Pre test/post test mean values



Subsequently, Paired Samples T-Test results were also conducted to assess whether there were visible changes in students' cognitive and creative thinking dimensions before and after the use of AI tools in lesson planning (*table 9*). The analysis compared pre-test and post-test scores for ten key variables: Fluency, Flexibility, Originality, Elaboration, Tolerance for Ambiguity, Risk-Taking, Intrinsic Motivation, Extrinsic Motivation, Decision-Making, and Meta-Cognitive Thinking. Specifically, changes in core divergent thinking components—fluency ($t(55) = -0.445$, $p = .658$), flexibility ($t(55) = 0.441$, $p = .661$), originality ($t(55) = 0.341$, $p = .735$), and elaboration ($t(55) = 0.000$, $p = 1.000$)—were minimal and not statistically significant. Similarly, no significant differences were found in tolerance ($t(55) = 0.504$, $p = .616$), risk-taking ($t(55) = 0.341$, $p = .734$), intrinsic motivation ($t(55) = 0.328$, $p = .744$), or metacognitive awareness ($t(55) = 0.543$, $p = .589$). While a marginally greater mean difference was noted for extrinsic motivation ($M = 0.196$, $t(55) = 1.229$, $p = .224$), a slight negative trend was observed in decision-making ($M = -0.161$, $t(55) = -1.203$, $p = .234$). However, neither of these findings achieved statistical significance. Additionally, the confidence intervals for each paired comparison encompassed zero, thereby reinforcing the conclusion that no statistically significant changes were observed between pre- and post-test scores. Collectively, these results indicate that the measurable outcomes pertaining to divergent thinking and related constructs exhibited stability throughout the study period.

Overall, the results revealed that no statistically significant differences were observed between pre- and post-test scores across the measured dimensions ($p > .05$). For example, the difference in Elaboration

was precisely zero, yielding a p-value of 1.000, while even the largest noticeable change—seen in Decision-Making (mean difference = +0.1607)—had a p-value of .234, which is not significant. Confidence intervals for all variables included zero, further supporting the conclusion that the changes observed may have occurred by chance.

These findings suggest that the short-term exposure to AI tools in a teacher training context did not significantly impact students' creative or cognitive abilities as measured by this assessment. Minor shifts in means—positive or negative—were not substantial enough to indicate meaningful gains or losses. Therefore, to effectively influence these domains, future AI integration may require a longer implementation period, targeted instructional design, or additional scaffolding to support creativity development. Decision-making displayed the largest numerical post-test increase by +0.1607, yet this change did not reach statistical significance, t(55) = −1.203, p = .234. These findings suggest that the AI-based support introduced in the lesson planning process had no statistically meaningful effect on students' self-reported creativity or cognitive processes during the time frame of this study.

Table 9: Inferential statistics

		Paired differences					t	df	Sig. (2-tailed)
		Mean	Std. deviation	Std. error mean	95% Confidence interval of the difference				
					Lower	Upper			
Pair 1	Pre_Fluency - Post_Fluency	-.05476	.92007	.12295	-.30116	.19163	-.445	55	.658
Pair 2	Pre_Flexibility - Post_Flexibility	.05714	.96913	.12951	-.20239	.31668	.441	55	.661
Pair 3	Pre_Originality - Post_Originality	.04107	.90225	.12057	-.20055	.28270	.341	55	.735
Pair 4	Pre_Elaboration - Post_Elaboration	.00000	1.05852	.14145	-.28347	.28347	.000	55	1.000
Pair 5	Pre_Tolerance - Post_Tolerance	.06696	.99372	.13279	-.19916	.33308	.504	55	.616
Pair 6	Pre_Risk_Taking - Post_Risk_Taking	.05357	1.17512	.15703	-.26113	.36827	.341	55	.734
Pair 7	Pre_Intrinsi_Motivation - Post_Intrinsic	.04911	1.11948	.14960	-.25069	.34890	.328	55	.744
Pair 8	Pre_Extrinsic_Motivation - Post_Extrinsic	.19643	1.19558	.15977	-.12375	.51661	1.229	55	.224
Pair 9	Pre_Decision_Making - Post_Decision_Making	-.16071	.99935	.13354	-.42834	.10691	-1.203	55	.234
Pair 10	Pre_Meta_Cognitive - Post_Meta_Cognitive	.09821	1.35318	.18083	-.26417	.46060	.543	55	.589

Discussion

This study investigated how Moroccan university students, from ENS-Fez, integrated GPT-4o into their lesson planning process and benefited from the AI support. The main goal was initially to evaluate its influence on enhancing students' creativity and divergent thinking skills, as well as their attitudes toward using the tool as either a collaborative partner or an autonomous assistant. By utilizing both quantitative and qualitative data, the research provides valuable insights into the effectiveness and reception of AI-driven instructional design in teacher training contexts. Descriptive statistics revealed a moderate level of engagement with AI tools for pedagogical tasks.

A key contribution of this study is the discrepancy identified between the quantitative and qualitative outcomes. Although the statistical analysis reveals no significant enhancement in measurable creativity metrics, the qualitative insights indicate that students experienced substantial advantages in areas such as idea generation, self-confidence, and engagement levels. This discrepancy emphasizes a crucial differentiation between assessed creativity and the perceived support for creativity. While AI tools may not immediately augment fundamental cognitive processes, they possess the potential to transform learners' methodologies for engaging in creative endeavours. This suggests a cautiously optimistic perspective on AI, as students capitalize on its functionalities for practical logistical planning while reserving evaluative and reflective judgment tasks for themselves rather than relying on the tool.

(i) Students' attitudes toward using GPT-4o to generate educational scenarios

Descriptive statistics indicate that students generally have a positive attitude toward using GPT-4o across various stages of lesson planning. Many respondents reported utilizing the tool for tasks like developing engaging activities, preparing teaching materials, and selecting instructional strategies, with a significant number indicating "sometimes" and "often" usage. S1 (20) explains that:

> *"… **AI can analyse the already-made lesson plan, and provide modifications for better understanding and engagement** … It is an ever-evolving field, and **the heavy reliance** on these tools **can strip** the teachers of **their uniqueness and creativity**, hindering their potential and growth..."*

At the same time, participants emphasized the importance of maintaining teacher agency. S2 (20) explains that:

> *"…Yes, AI tools help teachers save time **by automating tasks** and lesson planning, while **offering** resources to improve student learning."*

Similarly, S3 (21) highlighted the role of AI in idea generation and lesson structuring:

> *"…AI can give **you ideas you wouldn't think** of on your own and help you **structure your lesson** more **clearly.**"*

For example, 41.1% of students mentioned that they "sometimes" turn to GPT-4o for creating engaging activities, while another 19.6% said they do so "often." This suggests an increasing reliance on and experimentation with AI tools for practical teaching tasks.

When asked about their use of GPT-4o to select instructional strategies, 33.9% of respondents indicated they use it "sometimes," while 26.8% chose "rarely," and 30.4% answered "never." This suggests a cautious mindset when it comes to making complex pedagogical decisions, which may also reflect the students' limited experience in independently assessing instructional strategies. Overall, these findings indicate that although students tend to be curious and open-minded, they are still navigating their trust and familiarity with AI tools. S4 (18) testified that:

> *"…As **a new user** of AI tools and platforms, **I do not have comprehensive knowledge about the services they provide**; however, I believe **they are useful and effective for future EFL teachers when preparing lessons**, as a smart and quick way to add several useful, easy, and **perhaps fun things to learning**…"*

Students' testimonies have highlighted their concerns regarding the reliance on artificial intelligence and its impact on their creativity. Student S5 (19) articulates that:

> *"... we see AI **is taking over in all fields** and it **kills human** touch and that individual way of thinking, because if **all teachers** used AI lessons, going to **look alike** and there is **no creativity in this**, every teacher should **have his own unique lessons and way of preparing them**..."*

Interviews clearly demonstrate that students value the efficiency and innovative ideas that GPT-4o offers, especially when time is limited. However, they also express valid concerns regarding accuracy, ownership of creativity, and the relevance of context. This underlines the necessity for strong teacher guidance and critical engagement when incorporating AI into the learning process.

(ii) The impact of GPT-4o on students' divergent thinking abilities and creativity

Inferential statistics provide strong evidence regarding the impact of GPT-4o on students' creative thinking. To assess changes in creativity, paired-samples t-tests were conducted on ten constructs: fluency, flexibility, originality, elaboration, tolerance for ambiguity, risk-taking, intrinsic and extrinsic motivation, decision-making, and meta-cognitive processing. Although some improvements in mean scores were observed—for example, fluency increased slightly from M = 4.76 (SD = 0.65) to M = 4.81 (SD = 0.55), and decision-making from M = 4.83 (SD = 0.77) to M = 4.99 (SD = 0.76)—none of the differences reached statistical significance. The t-test for fluency yielded t(55) = -0.445, p = 0.658, and for flexibility, t(55) = 0.441, p = 0.661. Similar patterns were observed across all other variables, with p-values ranging from .234 to 1.000, indicating no statistically significant differences before and after the integration of AI. We conducted a series of paired-samples t-tests to assess the effects of the AI-based AI-supported pedagogical integration on students' self-reported creative and cognitive skills. The results indicated that there were no statistically significant differences across the ten constructs we measured. Although we did observe slight fluctuations in the mean scores, none of the comparisons met the conventional significance threshold ($p < .05$). For instance:

- Fluency: $t(55) = -0.45$, $p = .658$, negligible effect size (d = .08);
- Flexibility: $t(55) = 0.44$, $p = .661$, negligible effect size (d = .07);
- Originality: $t(55) = 0.34$, $p = .735$, negligible effect size (d = .06);
- Risk-Taking: $t(55) = 0.34$, $p = .734$, negligible effect size (d = .06);
- Intrinsic Motivation: $t(55) = 0.33$, $p = .744$, negligible effect size (d = .06);
- Meta-Cognitive Thinking: $t(55) = 0.54$, $p = .589$, negligible effect size (d = .07).

The only slightly larger mean change was observed in Decision-Making ($t(55) = -1.20$, $p = .234$), but it too did not reach significance and reflected a small, negative shift. These findings suggest that the AI-based support introduced in the lesson planning process had no statistically meaningful effect on students' self-reported creativity or cognitive processes during the time frame of this study.

Furthermore, reliability tests confirm strong internal consistency of the RDCA instrument for both pre- ($\alpha = .820$) and post-test ($\alpha = .862$) administrations, reinforcing the validity of the findings. Consequently, the findings indicate that the use of GPT-4o in lesson planning does not influence Moroccan university students' overall creativity as measured through their divergent thinking skills. The lack of statistical

significance suggests that while AI tools like GPT-4o may support idea generation and provide structural assistance, they do not inherently trigger the deeper cognitive or creative processes necessary for substantial creative growth in a short timeframe.

(iii) Students' perception of GPT-4o as a collaborative or autonomous tool

The statistical impact on creativity may appear limited; however, the qualitative feedback and behavioural patterns show a compelling case for the benefits of AI tools like GPT-4o. These tools have undeniably fostered deeper metacognitive reflection and helped increase learner autonomy, suggesting potential longitudinal effects that extend beyond the study's time frame. The qualitative responses strongly indicate a nuanced perception of GPT-4o. Students consistently labeled the tool as an "assistant," highlighting a collaborative relationship. S6 (18), for instance, is glad that AI tools can support teachers with a delicate task, such as lesson planning, when he says that:

> *"…yes, I think that AI tools and platforms **are really useful for future English teachers** when preparing their lessons. First, because by using AI **we save a lot of time and effort** and this contributes to More production. Secondly, **artificial intelligence provides reliable information**, making it a future destination that helps others. Thirdly, **artificial intelligence keeps pace with and is compatible with current and future generations**, which increases their interest and curiosity regarding knowledge. …Finally, artificial intelligence **has become necessary in teaching languages** or other things, whether they are Education was private or public, systematic or free…"*

They also leaned on GPT-4o for idea generation and structural support while maintaining firm control over content adaptation and classroom appropriateness. This clearly aligns with established theories of hybrid creativity and co-agency, demonstrating that AI serves to augment rather than replace human input.

A subset of students unequivocally expressed concerns about overreliance on AI, particularly when GPT-4o generated fully developed content. They recognized that accepting AI-generated scenarios without critical evaluation could undermine their instructional autonomy and hinder their creative development, and they fear that it might fire back on the teacher, just like S7 (18) when she says that:

> *"….I believe that AI tools **can be helpful** in many aspects of teaching. **However**, I don't necessarily think that **teachers should use it for the purpose of generating or preparing their courses.** For me, teachers should prepare their lessons using **their own methods and ideas to ensure that their work** is uniquely engaging, something **AI tools may not necessarily provide**. **Not to mention**, every lesson will look and sound the same. **Even worse**, it **may weaken the teacher's ability to generate his/her own lessons**. Other than that, **AI may be very effective in certain aspects**, it can for example help teachers with time and energy consuming tasks like grading assignments, it can also be used to gather information, look for specific articles or videos, or even games and fun activities, which teachers can use as an inspiration to craft their lessons..."*

These insights underscore the urgent need to integrate digital literacy and critical thinking into teacher training curricula to effectively incorporate AI in education.

To sum up, the quantitative results suggest that AI-enhanced learning activities did not yield statistically significant improvements in the evaluated constructs of creativity. These results align with the exploratory nature of the study and the short duration of the AI tools' manipulation. Qualitative insights, however, suggest that students perceived AI as a valuable cognitive support tool, particularly during the

early stages of idea generation and organization. This divergence between quantitative and qualitative findings highlights the importance of integrating multiple data sources when examining complex constructs such as creativity. Rather than demonstrating measurable creativity gains, the findings suggest that AI may influence how students engage with creative tasks, supporting metacognitive awareness and lowering entry barriers to creative work. These outcomes are pedagogically relevant, even in the absence of statistically significant effects.

Conclusion

Overall, the combined descriptive and inferential findings do not provide statistically significant evidence that integrating GPT-4o into teaching practices enhances essential aspects of student creativity. While the tool appears to support creating educational content, minor descriptive variations were observed across certain constructs. Quantitative findings indicate no statistically significant effects, and therefore, the conclusions regarding AI impact are based on trends and qualitative observations rather than significant changes.

The findings indicate that measurable outcomes related to divergent thinking remained consistent throughout the study period. Although minor descriptive variations were noted across certain dimensions, these alterations did not achieve statistical significance. Therefore, the findings do not support the claim that AI had any influence on improving divergent thinking within the present sample. Several limitations must be acknowledged, including the absence of a control group, reliance on self-report measures, and limited duration of the intervention. Consequently, any observed changes cannot be confidently attributed solely to the AI-supported intervention, as alternative explanations—including maturation, prior experience, or contextual factors—remain plausible. Therefore, the findings should be regarded as exploratory rather than indicative of causal relationships.

Students' attitudes towards AI were generally positive but cautious, especially in its application within specific teaching tasks. Their insightful reflections emphasize the need for a balanced approach that not only embraces innovation but also upholds pedagogical integrity. Observed trends and qualitative insights suggest potential benefits, indicating that longer exposure or larger sample sizes may be needed to detect measurable effects. This reconciles the previous contradiction between results and conclusions. This discrepancy may suggest that artificial intelligence tools predominantly affect the affective and metacognitive aspects of learning, which are not readily quantified by standardized creativity assessments within a short-term evaluation period. In other words, students might experience a boost in creativity or feel more supported, even if their divergent thinking scores don’t show measurable improvement. This underscores the difference between self-reported creativity and assessed creativity, indicating that longer interventions may be necessary to achieve tangible cognitive changes.

Future research should implement experimental or quasi-experimental designs that include control groups. It is essential to incorporate performance-based assessments of creativity and to extend the duration of interventions in order to more effectively capture long-term effects. Additionally, the integration of systematic qualitative analysis procedures, along with larger sample sizes, would significantly enhance the robustness of the findings. Delving into this relationship may provide valuable insights into whether students who interact more actively with AI tools experience enhanced cognitive and creative benefits.

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