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# Examining the impact of ChatGPT use on student engagement, critical thinking, and intrinsic motivation among students at Cadi Ayyad University, Morocco: A PLS-SEM study

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## ABSTRACT

The rapid proliferation of generative artificial intelligence, particularly ChatGPT, is transforming the nature of teaching and learning in higher education. However, empirical evidence regarding its impact on key educational outcomes remains limited. This study examines the effects of ChatGPT use on students' engagement in learning, critical thinking, and intrinsic motivation among students at Cadi Ayyad University in Morocco. This study adopted a quantitative research design involving a structured questionnaire administered to university students. Data were analyzed using partial least squares structural equation modeling (PLS-SEM) to assess the reliability and validity of the measurement model and to test the proposed hypotheses. The results indicated that the use of ChatGPT has significant positive effects on student engagement, critical thinking, and intrinsic motivation. In particular, the strongest effect was observed between ChatGPT use and critical thinking. These results suggest that ChatGPT can be an effective educational tool when appropriately integrated into higher education. These findings provide practical implications for higher education institutions seeking to integrate generative AI. Universities should promote the pedagogically guided and ethical use of ChatGPT by encouraging students to critically evaluate AI-generated content, develop reflective learning practices, and strengthen engagement and motivation while avoiding excessive cognitive dependence on AI tools.

**Contribution/Originality:** This study contributes to the existing literature by providing one of the first PLS-SEM empirical assessments of ChatGPT's effects on student engagement, critical thinking, and intrinsic motivation among Moroccan university students. It extends evidence from an underexplored higher education context.

## 1. INTRODUCTION

Artificial intelligence (AI) is seeing rapid adoption in many sectors, including healthcare, business, banking, commerce, transportation, and many others. Education is no exception to this transformation, with AI opening up vast possibilities. Not only can it automate many administrative tasks, but it is also bringing about a profound paradigm shift in teaching methods (Dhamija & Dhamija, 2025). According to Albadarin, Saqr, Pope, and Tukiainen (2024), over the past four decades, numerous studies have explored the integration of Artificial Intelligence (AI) into education. One recent and impactful AI-powered technology that has made a significant impact on the education sector is ChatGPT. Integrating ChatGPT into higher education plays a key role in students' learning, enhances their educational experiences, and promotes various teaching approaches (Kooli, 2023; Kuhail, Alturki, Alramlawi, &

Alhejori, 2023). Several authors have advocated for the adoption of innovative AI-inclusive strategies, emphasizing the urgent need for the higher education sector to adapt and evolve in response to the transformative impact of generative AI across various information-processing domains (Bozkurt, 2024), According to Youssef, Medhat, Abdellatif, and Al Malek (2024), ChatGPT stands out as a promising tool that fosters active student engagement and cognitive development by adapting to students' learning pace and offering continuous support throughout the knowledge acquisition process. This study contributes to the existing literature by providing one of the first PLS-SEM empirical assessments of ChatGPT's effects on student engagement, critical thinking, and intrinsic motivation among Moroccan university students. It extends evidence from an underexplored higher education context.

Thus, there has been a growing interest in studying students' perspectives on using ChatGPT, as it is one of the most advanced and widely used AI language models, in order to identify areas that universities should improve. Among these studies, those focused on student engagement stand out, as student engagement is considered a key educational outcome that may be influenced by the use of AI tools in learning and thus contributes to quality assurance systems by providing relevant insights into students and their academic experience (Pascarella, Seifert, & Blaich, 2010; Younis, 2024). Most research on student engagement has been primarily developed in Anglo-Saxon countries to better understand the link between this phenomenon and students' persistence in higher education, as well as its impact on their social and academic integration within the university. With the increasing use of technologies such as ChatGPT, this research is now evolving to examine how AI-driven tools can influence student engagement by providing more personalized learning experiences and supporting academic integration. Furthermore, these studies are also used to analyze current processes for improving higher education in countries such as the United States. Since similar processes are also being implemented in Chile and, more broadly, in Latin America, research on student engagement becomes particularly relevant for this region of the continent, especially considering the lack of studies in this field (Pineda-Báez et al., 2014). To address this gap, the present study investigates the impact of ChatGPT use on student engagement, critical thinking, and intrinsic motivation among students of the Cadi Ayyad university in Morocco using a PLS-SEM approach.

Although ChatGPT is increasingly used in higher education as a tool for personalized assistance, writing support, feedback, and access to information, its effects on student engagement remain complex and debated. While some studies suggest that ChatGPT can enhance motivation, participation, self-regulation, and cognitive involvement, others emphasize risks related to overreliance, academic integrity, plagiarism, misinformation, and reduced critical thinking. This raises the need to better understand how students use ChatGPT and how this use influences the behavioral, emotional, and cognitive dimensions of their engagement in higher education.

## 2. LITERATURE REVIEW

Artificial intelligence (AI) is increasingly integrated into higher education, where it is used to optimize pedagogical methods, enrich learning experiences, and simplify administrative processes (Crompton & Burke, 2023; Zafari, Bazargani, Sadeghi-Niaraki, & Choi, 2022). Among the various artificial intelligence tools, current large language models such as ChatGPT, Gemini, Claude, and LLaMA have attracted particular attention for their ability to generate text, answer questions, provide explanations, and support academic activities. These tools rely on large language models and deep learning techniques that enable them to process natural language and produce coherent responses (Brown et al., 2020; Radford et al., 2019; Tayan, Hassan, Khankan, & Askool, 2024; Wang, Dang, Wu, & Mac, 2024).

Among these tools, ChatGPT and Gemini, formerly known as Bard before 2024, stand out for their ability to provide valuable insights and practical support in educational contexts. These tools are gaining increasing attention because of their potential applications in teaching, learning, writing support, feedback, and knowledge acquisition (Garg, Ahmad, & Madsen, 2024). Developed by OpenAI, ChatGPT is an artificial intelligence-based language model that relies on the GPT architecture. It generates human-like responses to users' inquiries and commands by using

deep learning and machine learning algorithms to simulate natural conversations (Azaria, Azoulay, & Reches, 2024; Haleem, Javaid, & Singh, 2022).

The release of ChatGPT has transformed the tools and applications used for academic writing, learning assistance, and knowledge exploration. Compared to earlier chatbots, ChatGPT provides more flexible, contextualized, and interactive responses, which explains its growing use in higher education. The literature suggests that ChatGPT can enhance student motivation and engagement in learning processes by providing immediate feedback and creating a more interactive learning environment (Kasneci et al., 2023).

### *2.1. ChatGPT in Education*

Early educational chatbots have been used as text-based conversational agents, particularly in language-learning contexts. However, their limited conversational capabilities could result in repetitive, irrelevant, or contextually inappropriate responses, thereby reducing the quality of the learning experience (Fryer, Ainley, Thompson, Gibson, & Sherlock, 2017; Yin, Goh, Yang, & Xiaobin, 2021). Therefore, students had relatively limited engagement with chatbots due to their restricted educational value. With the advance of generative AI, AI-powered chatbots have developed enhanced conversational capabilities. ChatGPT, built on large language model technology, was launched to support natural language processing and allows users to interact with it through conversational language (Chiu, 2024). Unlike older rule-based chatbots, which provide predefined and fixed responses based on students' inputs, ChatGPT can flexibly handle more complex and adaptable contexts (Ng, Leung, Chu, & Qiao, 2024). Relevant studies have highlighted the potential of ChatGPT in supporting group interactions in online learning environments by facilitating discussions and providing explanations on specific topics (Javaid, Haleem, Singh, Khan, & Khan, 2023; Younis, 2024). It can handle spontaneous interactions with multiple users and support collaborative learning activities. Some educators have used ChatGPT as a personalized feedback tool to guide students through learning activities, while others have treated it as an intelligent tutoring system capable of providing relevant information, learning materials, and support for adaptive learning and self-regulation.

### *2.2. ChatGPT and Students' Engagement*

Student engagement is widely considered a multidimensional construct that includes behavioral, emotional, cognitive, and sometimes social dimensions (Bond & Bergdahl, 2022; Christenson, Reschly, & Wylie, 2012; Fredricks, Blumenfeld, & Paris, 2004). In higher education, engaged students actively participate in learning activities, interact with peers and instructors, show interest and motivation, and invest cognitive effort in understanding and mastering academic content (Kahu, 2013; Sinatra, Heddy, & Lombardi, 2015). In this context, ChatGPT may contribute to student engagement by providing immediate feedback, personalized explanations, writing support, and opportunities for interactive learning (Javaid et al., 2023; Kasneci et al., 2023). Through its conversational and adaptive capabilities, ChatGPT can encourage students to ask questions, clarify difficult concepts, participate in discussions, and regulate their own learning process. Therefore, when used strategically, ChatGPT can support behavioral engagement through participation, emotional engagement through motivation and interest, and cognitive engagement through reflection, self-regulation, and deeper processing of information.

*$H_1$: ChatGPT use has a positive and significant effect on student engagement.*

ChatGPT promotes interactive and personalized learning experiences by providing immediate feedback, facilitating communication, and supporting self-regulated learning. These characteristics may increase students' behavioral, emotional, and cognitive engagement throughout the learning process (Kooli, 2023; Lo, Hew, & Jong, 2024; Younis, 2024).

### *2.3. ChatGPT and Intrinsic Motivation*

Intrinsic motivation refers to students' internal willingness to engage in learning activities for reasons such as curiosity, interest, personal satisfaction, and the desire to understand or master academic content. In the context of higher education, ChatGPT may support intrinsic motivation by making learning more interactive, accessible, and personalized. Atlas (2023) highlights the potential of ChatGPT and similar language models in academic writing, language learning, research support, and administrative tasks. Similarly, Adiguzel, Kaya, and Cansu (2023) argue that ChatGPT offers several opportunities for learners, including increased intrinsic motivation, deeper understanding of concepts, and the development of expertise. By providing immediate explanations, personalized feedback, and continuous support, ChatGPT can help students overcome learning difficulties, stimulate curiosity, and encourage more active involvement in the learning process. Therefore, when used appropriately, ChatGPT may contribute to strengthening students' intrinsic motivation by supporting autonomy, competence, and interest in learning.

*$H_2$: ChatGPT use has a positive and significant effect on students' intrinsic motivation.*

The conversational and adaptive capabilities of ChatGPT may enhance students' intrinsic motivation by increasing curiosity, autonomy, perceived competence, and confidence during learning activities. Previous studies have shown that AI-assisted learning environments can foster greater motivation and willingness to participate in academic tasks (Adiguzel et al., 2023; Atlas, 2023; Deng, Jiang, Yu, Lu, & Liu, 2025).

### *2.4. ChatGPT and Critical Thinking*

Critical thinking is widely recognized as one of the most essential higher-order cognitive skills in higher education, enabling students to analyze information, evaluate evidence, construct logical arguments, and make reasoned decisions (Ennis, 2018; Facione, 1990, 2011). Rather than merely acquiring knowledge, critical thinking encourages learners to question assumptions, assess the credibility of information sources, identify biases, and solve complex problems through reflective and analytical reasoning (Paul & Elder, 2020). Consequently, it has become a key competency for lifelong learning and for preparing graduates to navigate increasingly complex digital and information-rich environments.

The rapid adoption of generative artificial intelligence, particularly ChatGPT, has renewed scholarly interest in understanding its influence on students' critical thinking. On the one hand, ChatGPT can facilitate analytical reasoning by providing immediate explanations, encouraging reflection, generating alternative viewpoints, and supporting argument development (Javaid et al., 2023; Kasneci et al., 2023). When integrated into well-designed learning activities, ChatGPT may stimulate students to evaluate AI-generated responses, compare multiple perspectives, and engage in evidence-based reasoning, thereby fostering critical thinking skills (Li, Cui, & Hagedorn, 2026). On the other hand, several scholars argue that excessive reliance on ChatGPT may reduce students' independent reasoning, encourage superficial information processing, and promote cognitive offloading, ultimately weakening critical thinking abilities (Lo et al., 2024; Vargas-Murillo, De La Asuncion, & De Jesús Guevara-Soto, 2023; Zirar, 2023).

Recent systematic reviews suggest that the cognitive effects of ChatGPT depend largely on pedagogical design and instructional scaffolding rather than on the technology itself. Li et al. (2026), in a systematic review of 67 empirical studies, conclude that ChatGPT supports critical thinking when learners are encouraged to critically evaluate AI-generated outputs, justify their decisions, and engage in reflective dialogue. Conversely, unguided use is associated with cognitive dependency and reduced epistemic engagement. Despite these advances, existing research has generally examined critical thinking alongside broader educational outcomes such as student engagement, academic performance, or higher-order thinking, leaving limited empirical evidence on the specific relationship between ChatGPT use and students' critical thinking in higher education. This study seeks to contribute to this emerging body of knowledge by examining critical thinking as a distinct cognitive outcome associated with ChatGPT use.

*$H_3$: ChatGPT use has a positive and significant effect on students' critical thinking.*

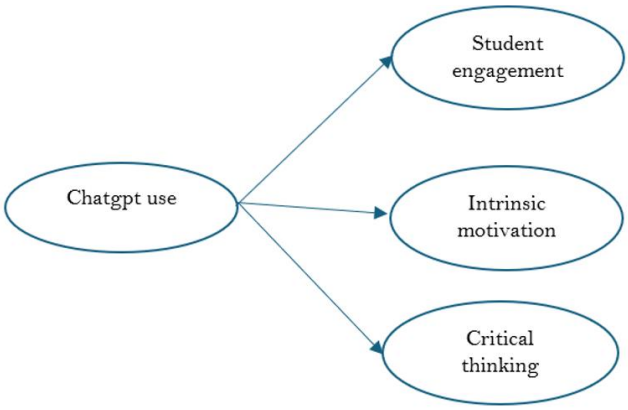


**Figure 1.** The proposed model.

Figure 1 illustrates the proposed conceptual model of the study. The model conceptualizes ChatGPT use as the independent construct and student engagement, intrinsic motivation, and student critical thinking as the dependent constructs. Based on the literature review, three hypotheses (H1–H3) were developed to examine the positive effects of ChatGPT use on these educational outcomes using the PLS-SEM approach.

*$H_1$: ChatGPT use has a positive and significant effect on student engagement.*

*$H_2$: ChatGPT use has a positive and significant effect on intrinsic motivation.*

*$H_3$: ChatGPT use has a positive and significant effect on students' critical thinking.*

## 3. RESEARCH METHODOLOGY

This study adopted a quantitative approach based on a survey conducted among Moroccan students enrolled in higher education institutions. The final sample consisted of 174 university students who completed the questionnaire. Data were collected using a structured questionnaire designed to measure students' use of ChatGPT and its effects on student engagement, critical thinking, and intrinsic motivation. The conceptual model included ChatGPT use as the exogenous variable, while student engagement, critical thinking, and intrinsic motivation were treated as endogenous variables. For data analysis, we used partial least squares structural equation modeling (PLS-SEM), which is well-suited for evaluating predictive models and the relationships among latent variables measured by multiple indicators.

The analysis was conducted in two main steps. First, the measurement model was evaluated in terms of the reliability, internal consistency, convergent validity, and discriminant validity of the indicators. Next, the structural model was evaluated using collinearity diagnostics, the coefficient of determination ($R^2$), effect size ($f^2$), predictive validity ($Q^2$), and path coefficients obtained via the bootstrap method.

## 4. RESULTS

### *4.1. Measurement Model*

The measurement model was assessed by examining internal consistency reliability, convergent validity, and discriminant validity. Tables 1 and 2 summarize the results of these assessments.

**Table 1.** Construct Reliability and Convergent Validity.

| Construct | Cronbach alpha | rho_a | rho_c | AVE |
|---|---|---|---|---|
| Student engagement | 0.852 | 0.709 | 0.852 | 0.743 |
| Critical thinking | 0.890 | 0.894 | 0.924 | 0.751 |
| Intrinsic motivation | 0.889 | 0.896 | 0.923 | 0.749 |
| ChatGPT use | 0.742 | 0.899 | 0.800 | 0.766 |

Table 1 presents the internal consistency reliability and convergent validity assessment of the measurement model. Cronbach's alpha values range from 0.742 to 0.890, Composite Reliability (CR) values range from 0.800 to 0.924, and all AVE values exceed the recommended threshold of 0.50, confirming satisfactory reliability and convergent validity.

**Table 2.** Heterotrait-monotrait ratio.

| Relationship | HTMT |
|---|---|
| Critical thinking <-> Student engagement | 0.739 |
| Intrinsic motivation <-> Student engagement | 0.722 |
| Intrinsic motivation <-> Critical thinking | 0.663 |
| ChatGPT use <-> Student engagement | 0.827 |
| ChatGPT use <-> Critical thinking | 0.754 |
| ChatGPT use <-> Intrinsic motivation | 0.692 |

Table 2 presents the results of the discriminant validity using the Heterotrait–Monotrait (HTMT) ratio. All HTMT values range from 0.663 to 0.827, remaining below the recommended threshold of 0.90. These results confirm that the constructs are empirically distinct and demonstrate satisfactory discriminant validity.

### *4.2. Structural Model*

After confirming the adequacy of the measurement model, the structural model was evaluated. Collinearity diagnostics indicated that the VIF values were below the recommended threshold of 3, suggesting the absence of multicollinearity among the predictor constructs. The structural model was then assessed using the coefficient of determination ($R^2$), effect size ($f^2$), predictive relevance ($Q^2$), and hypothesis testing.

**Table 3.** Coefficient of Determination ($R^2$)

| Endogenous construct | $R^2$ | Adjusted $R^2$ |
|---|---|---|
| Student engagement | 0.297 | 0.293 |
| Critical thinking | 0.497 | 0.494 |
| Intrinsic motivation | 0.446 | 0.443 |

Table 3 presents the coefficients of determination ($R^2$) and adjusted coefficients of determination (Adjusted $R^2$) for the endogenous constructs. The results indicate that ChatGPT use explains 29.7% of the variance in student engagement, 49.7% of the variance in critical thinking, and 44.6% of the variance in Intrinsic motivation. The adjusted $R^2$ values are very close to the corresponding $R^2$ values, indicating the stability and explanatory power of the structural model.

**Table 4.** Effect Size ($f^2$) Results.

| Path | $f^2$ |
|---|---|
| ChatGPT use -> Student engagement | 0.422 |
| ChatGPT use -> Critical thinking | 0.989 |
| ChatGPT use -> Intrinsic motivation | 0.804 |

Table 4 presents the effect size ($f^2$) of the structural relationships. The results indicate that ChatGPT use has a substantial effect on student engagement ($f^2 = 0.422$) and strong effects on critical thinking ($f^2 = 0.989$) and students' intrinsic motivation ($f^2 = 0.804$). These findings suggest that ChatGPT use contributes meaningfully to explaining the variance in the three endogenous constructs, with the strongest effect observed for critical thinking.

**Table 5.** Predictive Relevance ($Q^2$predict) Assessment.

| Construct | $Q^2$predict | RMSE | MAE |
|---|---|---|---|
| Student engagement | 0.282 | 0.857 | 0.678 |
| Critical thinking | 0.487 | 0.726 | 0.560 |
| Intrinsic motivation | 0.436 | 0.760 | 0.581 |

Table 5 presents the predictive relevance ($Q^2$predict) results of the structural model. All $Q^2$predict values are positive, ranging from 0.282 to 0.487, indicating that the proposed model has satisfactory predictive relevance for all endogenous constructs.

**Table 6.** Hypotheses testing.

| Hypothesis | Path | β | t-value | p-value | Decision |
|---|---|---|---|---|---|
| H1 | ChatGPT use -> Student engagement | 0.545 | 8.137 | < 0.001 | Supported |
| H2 | ChatGPT use -> Intrinsic motivation | 0.668 | 13.021 | < 0.001 | Supported |
| H3 | ChatGPT use -> Critical thinking | 0.705 | 16.312 | < 0.001 | Supported |

Table 6 presents the results of hypothesis testing. Bootstrapping with 5,000 subsamples was used to test the significance of the structural paths. The results show that all hypotheses are supported as the path coefficients are positive and statistically significant ($p < 0.001$).

*H1: ChatGPT Use → Student Engagement*

The coefficient $\beta = 0.545$ indicates that the use of ChatGPT has a substantial positive effect on student engagement. This means that the more students use ChatGPT, the more their level of engagement in learning activities tends to increase. $P < 0.001$ shows that this relationship is statistically significant. Therefore, the hypothesis is supported.

*H2: ChatGPT Use → Intrinsic Motivation*

The coefficient $\beta = 0.668$ indicates that the use of ChatGPT has a strong positive effect on students' intrinsic motivation. This means that the use of ChatGPT contributes positively to enhancing students' willingness, interest, and motivation in learning activities. $P < 0.001$ indicates that this relationship is statistically significant. Therefore, the hypothesis is supported.

*H3: ChatGPT Use → Critical Thinking*

The coefficient $\beta = 0.705$ reveals a very strong positive effect of ChatGPT use on students' critical thinking. This result suggests that the use of ChatGPT is strongly associated with an improvement in students' ability to analyze, question, and structure their ideas. $P < 0.001$ confirms that this relationship is statistically significant. Therefore, the hypothesis is supported.

## 5. DISCUSSION

The findings of this study indicate that ChatGPT use positively influences student engagement, critical thinking, and intrinsic motivation. These results are consistent with recent research showing that generative AI can support learning processes in higher education when it is used as a pedagogical support tool rather than as a substitute for students' own cognitive effort (Javaid et al., 2023; Kasneci et al., 2023; Kooli, 2023). The strongest effect was observed for critical thinking. This finding supports previous studies suggesting that ChatGPT can enhance students' analytical and reflective abilities by encouraging them to question, compare, verify, and structure information. Li et al. (2026), for example, showed that ChatGPT may foster critical thinking when it is embedded in guided learning tasks involving reflection, argumentation, verification, and metacognitive regulation. Similarly, Lo et al. (2024) found that ChatGPT can contribute to cognitive engagement, although its effects on critical thinking remain mixed depending on the instructional context. Therefore, the present result confirms that ChatGPT can support higher-order thinking, but mainly when students use it critically and not passively. The positive effect of ChatGPT use on

student engagement is also aligned with prior research. Several studies have shown that ChatGPT can increase students' involvement in learning activities by providing immediate feedback, personalized explanations, and interactive academic support (Kooli, 2023; Lo et al., 2024; Younis, 2024). This result suggests that ChatGPT may encourage students to participate more actively, ask questions, clarify difficult concepts, and remain engaged in academic tasks. However, in line with Vargas-Murillo et al. (2023) and Zirar (2023), this effect should be interpreted with caution, because excessive reliance on ChatGPT may reduce students' autonomy and weaken deep engagement if the tool is used mainly to generate ready-made answers. The positive effect on student intrinsic motivation is consistent with previous research emphasizing the motivational potential of AI-assisted learning environments. Atlas (2023) and Adiguzel et al. (2023) argue that ChatGPT can increase students' curiosity, confidence, autonomy, and perceived competence by making learning more accessible and personalized. Similarly, Deng et al. (2025) found that ChatGPT-supported learning may improve intrinsic motivation and academic outcomes. In this study, the positive relationship between ChatGPT use and intrinsic motivation suggests that students may feel more confident and willing to learn when they receive immediate explanations and support adapted to their needs. Overall, these findings confirm that ChatGPT can play a positive role in higher education by supporting critical thinking, engagement, and intrinsic motivation. Nevertheless, they also reinforce the conclusions of previous studies indicating that the educational value of ChatGPT depends on pedagogical design, AI literacy, and responsible use. Without guidance, ChatGPT may encourage cognitive offloading, superficial learning, and dependency. Therefore, universities should not only encourage the use of generative AI but also train students to use it critically, ethically, and reflectively.

## 6. CONCLUSION

This article examined the impact of ChatGPT use on student engagement, critical thinking, and intrinsic motivation in higher education. The results of the PLS-SEM analysis indicate that ChatGPT use has positive and significant effects on the three outcomes. The study contributes to the literature by showing that ChatGPT may support not only engagement and intrinsic motivation, but also critical thinking, which is a central competence in AI-mediated learning environments. From a practical perspective, higher education institutions should not treat ChatGPT merely as a technological tool but as a pedagogical resource that requires structured integration. Teachers should encourage students to verify AI-generated content, compare responses, justify their reasoning, and use ChatGPT as a dialogic partner rather than as an answer provider. Future research could test more complex models, including mediation effects, AI literacy, self-regulated learning, and academic performance.

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**Institutional Review Board Statement:** The study involved minimal risk and followed ethical guidelines for social science fieldwork. Institutional approval for the study was obtained from the Dean of the Faculty of Legal, Economic and Social Sciences [Cadi Ayyad University (Université Cadi Ayyad), Morocco]. Participants were informed about the purpose of the study, the voluntary nature of their participation, and the confidentiality of their responses. Informed consent was obtained before they proceeded with the online questionnaire.
**Transparency:** The authors state that the manuscript is honest, truthful, and transparent, that no key aspects of the investigation have been omitted, and that any differences from the study as planned have been clarified. This study followed all writing ethics.
**Competing Interests:** The authors declare that they have no competing interests.
**Authors' Contributions:** Both authors contributed equally to the conception and design of the study. Both authors have read and agreed to the published version of the manuscript.

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