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The predictive role of artificial intelligence applications in enhancing psychological flourishing & sustainable development among Fayoum University students

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Abstract

Purpose This study examines the extent to which artificial intelligence (AI) applications predict psychological flourishing and sustainable development among Fayoum University students. It further explores gender differences in AI usage, flourishing levels, and sustainability orientations, as well as the interrelationships among the three variables.

Methods A quantitative correlational design was employed using validated scales measuring AI application use, psychological flourishing, and sustainable development. The sample consisted of 190 university students from Fayoum University (Egypt) there ages were between 20 and 25 years. The mean age was 22.54 years, with a standard deviation of 3.22 years. Data were analyzed using t-tests, Pearson's correlation coefficients, and simple linear regression to test the study hypotheses.

Results Findings revealed no significant gender differences in AI application use, while significant differences were found in psychological flourishing and sustainable development in favor of male students. Significant positive correlations emerged among AI use, flourishing, and sustainability. Regression analyses showed that AI application use moderately predicted psychological flourishing ($R^2 = 0.098$) but strongly predicted sustainable development ($R^2 = 0.604$), indicating that AI plays a substantial role in shaping students' sustainability-related behaviors.

Conclusions The study demonstrates that AI applications contribute meaningfully to enhancing students' well-being and sustainability practices, with a stronger influence on sustainability outcomes. These findings underscore the growing relevance of AI-driven learning environments in promoting sustainable education and student development.

Implications The results highlight the need for integrating AI-based tools into higher education policies, fostering responsible AI use, and developing institutional initiatives that enhance students' well-being and sustainability competencies.

Keywords Artificial intelligence applications, Psychological flourishing, Sustainable development, University students, Predictive analysis

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Introduction

In an era in which technology constitutes the cornerstone of human advancement, artificial intelligence has emerged as one of the most transformative and compelling scientific achievements. Artificial intelligence is no longer merely a technical tool; it has become a cultural, economic, social & psychological phenomenon that is reshaping the ways in which individuals interact with the world around them. Recent reports indicate that the global artificial intelligence market is expected to reach 190 billion USD by 2025, reflecting the expanding integration of this technology across all domains of life [1].

With the growing reliance of university students on these digital technologies, fundamental questions arise regarding their psychological and social implications: Can artificial intelligence contribute to enhancing psychological flourishing among university students? and can it serve as an effective tool for achieving sustainable development goals? These questions constitute the starting point of the present study, which seeks to explore the relationship between the use of artificial intelligence applications, on the one hand, and both psychological flourishing and sustainable development, on the other.

Artificial intelligence applications possess the capacity to analyze vast amounts of data, enabling the identification of patterns and trends that can inform strategies to enhance students' psychological well-being and promote sustainable practices within academic environments.

By employing machine learning algorithms and predictive analytics; universities can design targeted interventions that address the specific needs of their students, thereby fostering a healthier and more sustainable university culture [2].

The integration of artificial intelligence applications in higher education plays a pivotal role in predicting psychological flourishing and promoting sustainable development among university students. AI tools can enhance students' psychological well-being by providing personalized support and resources, while simultaneously fostering sustainable practices through innovative educational methodologies. The following sections will elaborate on these key aspects.

Artificial intelligence & psychological flourishing

The concept of psychological flourishing refers to a state in which individuals experience mental well-being and life satisfaction, while realizing their full potential at personal, social, and academic levels.

At the applied level, artificial intelligence has become an effective tool for providing digital psychological counseling, with chatbots and virtual assistants offering immediate support to students, thereby enhancing their psychological well-being [2]. Furthermore, Zhai et al. [3] demonstrated that machine learning algorithms can predict students' psychological states, such as depression and anxiety, by analyzing data on sleep patterns, academic performance, and social interactions, this enables universities to develop early interventions to support at-risk students.

Artificial intelligence has emerged as a powerful tool for predicting mental health outcomes among university students. Machine learning algorithms, such as Random Forests and Extreme Gradient Boosting (XGBoost), have been successfully applied to identify predictors of psychological distress, including demographic factors, lifestyle habits, and academic performance [3–5]. These models have achieved high accuracy in detecting early signs of anxiety, depression, and other psychological challenges, enabling timely interventions [5, 6].

Artificial intelligence has emerged as a powerful tool for predicting mental health outcomes, including depression, anxiety, and stress, which are prevalent among university students. Machine learning algorithms can analyze vast amounts of data, such as electronic health records (EHRs), mood assessment measures, and social media activity, to identify patterns indicative of mental health issues [7]. For instance, deep learning techniques have been successfully applied to EHRs to predict diseases such as diabetes, schizophrenia, and certain types of cancer, highlighting their potential for forecasting psychological conditions [8].

A systematic review conducted by Zafar [9] affirmed the transformative potential of artificial intelligence in promoting students' psychological well-being, while emphasizing the need for careful consideration of ethical concerns and contextual barriers that may limit its effective implementation.

Bhattacharjee [1] demonstrated that artificial intelligence can contribute to enhancing psychological flourishing by providing emotional, psychological & cognitive support, assisting students in managing stress and anxiety, so the artificial intelligence applications can assist students in managing stress and anxiety by providing personalized mental health resources and interventions.

Students' mental health issues are directly linked to societal stability and development. As societies evolve and educational competition intensifies, students face increasing psychological pressures, which exacerbate mental health problems. These challenges negatively affect not only their academic performance and personal lives but also society. Supporting students' mental health through artificial intelligence and big data analytics involves research and analysis in these domains. Based on the identified mental health support needs and the prediction of psychological crises, appropriate algorithms and models are designed to implement AI and big data analytics within student mental health support systems. The use of AI and big data represents an innovative

solution to enhance personalized mental health support, improve crisis prediction, and address the mental health challenges faced by students more effectively. This, in turn, indirectly contributes to fostering psychological flourishing and promoting sustainable development among university students by meeting their specific mental health needs [10].

Tools such as chatbots and virtual assistants provide immediate support, improving access to mental health services [11]. Additionally, predictive analytics can identify at-risk students, enabling timely interventions to enhance their psychological resilience [12].

AI-based interventions for enhancing mental health

The role of artificial intelligence extends beyond prediction to include the provision of targeted interventions aimed at improving mental health outcomes. Internet- and computer-based interventions, often grounded in cognitive-behavioral therapy (CBT), have demonstrated efficacy in reducing symptoms of depression, anxiety, and stress among university students. These interventions show substantial effectiveness compared to inactive control groups, with significant improvements observed in mental health outcomes [13].

The ability of artificial intelligence to personalize interventions represents a significant advantage.

By analyzing individual characteristics, such as behaviors, preferences, and responses to previous interventions, AI can design treatment plans tailored to each student's unique needs. This personalized approach not only enhances the effectiveness of interventions but also increases student engagement and adherence to the therapeutic process [13, 14].

Nguyen et al. [2] conducted a study aimed at highlighting the role of artificial intelligence applications in enhancing students' psychological well-being by providing timely support and guidance. The study emphasized that AI represents a promising domain in educational technology, offering students around-the-clock guidance to promote their mental health.

Zafar [9] conducted a study aimed at shedding light on the role of artificial intelligence applications in enhancing psychological well-being. The results concluded that integrating AI with behavioral therapy principles holds substantial promise for advancing mental health services for university students.

Abdillah and Madjid [15], in their exploratory study on enhancing students' psychological flourishing using artificial intelligence applications, including ChatGPT, in smart learning environments at universities, the study conducted a comprehensive literature review to examine relevant research and sources on this topic. The findings indicated that integrating AI ChatGPT into educational settings can provide multiple benefits for students, such as:

- Offering emotional support and assisting students in managing stress and anxiety related to their studies.
- Allowing students to seek guidance and support whenever needed, thereby enhancing overall well-being.
- Personalizing responses and support according to individual student needs, fostering a more tailored learning experience.

Artificial intelligence and sustainable development

Okulicz-Kozaryn et al. [16] indicated that universities have begun using artificial intelligence (AI) tools to enhance the quality of higher education service.

In addition to its role in promoting psychological well-being, artificial intelligence (AI) is a pivotal tool for achieving sustainable development in higher education. According to Khan et al. [17], AI applications help optimize resource consumption, reduce the environmental impact of universities, and enhance smart learning strategies, thereby contributing to the development of more sustainable educational institutions.

Sustainable development in the context of university students encompasses not only mental health but also academic success and social integration. AI can play a central role in enhancing these aspects by providing tools that support learning, academic planning, and social engagement. For example, machine learning algorithms can analyze academic performance data to identify students at risk of underachievement. By predicting these outcomes, AI can enable early interventions, such as personalized learning plans or academic advising, to help students stay on track [18]. Furthermore, AI-supported platforms can facilitate social interactions among students, reducing feelings of isolation and fostering a sense of community [7].

Ghosh [19] demonstrated that artificial intelligence (AI) can promote sustainable development by providing innovative learning opportunities, enhancing critical thinking, and supporting problem-solving skills, thereby preparing students to address future environmental and social challenges.

In this context, AI-supported educational systems play a key role in personalizing the learning experience for each student, enabling more efficient allocation of educational resources, reducing waste, and enhancing inclusivity in higher education [11].

Ghosh [19] highlighted that the implementation of artificial intelligence (AI) can be leveraged to provide innovative and engaging learning opportunities that foster critical thinking, problem-solving, collaboration, and equip students with the knowledge and skills required to

build a more sustainable future, The study emphasized that AI plays a crucial role in promoting education for sustainable development by enabling institutions to create engaging and innovative learning experiences that enhance students' critical thinking and problem-solving abilities.

Khan et al. [17] indicated that as higher education faces technological advancements and environmental demands, artificial intelligence (AI) becomes a pivotal tool for transforming teaching methods and institutional processes. The study's findings suggested that AI can enhance educational outcomes, resource management, and long-term sustainability in higher education by demonstrating how AI-driven innovations can reduce environmental impact, improve energy efficiency, and personalize learning experiences, thereby creating a more sustainable and inclusive academic environment, the results concluded that emphasizing AI and sustainability lays the foundation for a future in which technological advancement is aligned with environmental stewardship, ensuring the flourishing of higher education institutions in a rapidly changing world.

Abou et al. [11] conducted a statistical analysis of several studies examining the use of artificial intelligence (AI) in management and teaching systems in alignment with universities' roles in achieving sustainable development. This research proposed a comprehensive and integrated model for smart universities, where AI is employed to transform administrative and instructional systems in accordance with the Sustainable Development Goals (SDGs). Through a systematic analysis of AI applications in leading global universities, the findings emphasized AI's role in promoting sustainable development by addressing institutional challenges, automating quality assurance, and personalizing the learning process to meet students' individual needs.

Studies of Fošner [20] & Nikolopoulou [21] reported that the integration of generative artificial intelligence (AI) in higher education can lead to improvements in sustainability, including the enhancement of educational practices (e.g., personalized learning, automated assessment and feedback, and professional development for instructors), more efficient use of resources (such as digital educational materials and energy efficiency), support for inclusive and accessible education, and increased environmental awareness. Inclusivehese contributions, generative AI can help create educational environments that are more efficient, inclusive, and sustainable, AI applications in universities can automate administrative tasks and personalize learning experiences, in alignment with the Sustainable Development Goals [11].

Also, Chemlal and Azzouazi [22] indicated that artificial intelligence has become a key tool for supporting sustainable development in the education sector by optimizing resource consumption, enhancing smart learning strategies, and raising students' environmental awareness.

Recent scholarship points to an increasing diversity in the use of artificial intelligence across educational and psychological research. Broadly, these applications can be grouped into two main categories: generative AI tools and AI-based correction and detection systems. Each category serves a different purpose and entails distinct methodological and ethical considerations.

Generative AI tools, including large language models, are designed to create new outputs-such as text, images, or simulated scenarios-by drawing on patterns learned from large-scale datasets. Within research settings, these tools may assist with tasks such as idea development, data exploration, or scenario-based modelling. At the same time, their capacity to generate content raises important concerns related to bias, reliability, transparency, and the risk of excessive reliance, particularly when their use is not accompanied by careful human judgment [23, 24].

By contrast, AI-based correction and detection tools serve primarily analytic and evaluative functions. These systems focus on reviewing and monitoring existing material, for example by identifying plagiarism, detecting AI-generated content, or enhancing linguistic accuracy. Rather than contributing to content creation, their primary role is to support research integrity, strengthen quality assurance processes, and promote adherence to ethical standards [24, 25].

However, as reliance on these technologies continues to grow, important questions emerge regarding their psychological and social impact. Specifically, can artificial intelligence contribute to enhancing psychological flourishing and sustainable development among university students? This question serves as the starting point for the present study, which aims to examine the relationships between AI application use, psychological flourishing, and sustainable development. Additionally, the study investigates the predictive role of AI application use in shaping both psychological flourishing and sustainable development among students at Fayoum University in Egypt.

The purpose of the present study is to investigate the role of artificial intelligence (AI) applications in promoting psychological flourishing and sustainable development among university students. Specifically, the study seeks to examine potential gender-based differences in the use of AI applications, levels of psychological flourishing, and indicators of sustainable development. Furthermore, it aims to elucidate the nature, direction, and strength of the relationships between AI application use and both psychological flourishing and sustainable development. In addition, the study intends to determine the

predictive capacity of AI application use in accounting for variations in these outcomes. Ultimately, the research aspires to provide evidence-based and actionable recommendations for enhancing the positive psychological and developmental effects associated with the effective and responsible integration of AI technologies in higher education contexts.

Accordingly, based on the above, problem of the current study can be formulated around answering the following three research questions:

Are there statistically significant differences in AI application usage, psychological flourishing, and sustainable development among the study sample based on gender?

Is there a statistically significant correlation between AI application usage, psychological flourishing, and sustainable development among the study sample?

Does the use of AI applications contribute to predicting psychological flourishing and sustainable development among the study sample?

Research gap

Despite the growing body of research on the application of artificial intelligence (AI) in higher education, a critical review of the literature reveals several notable gaps that remain insufficiently explored. Most prior studies have predominantly examined the role of AI in enhancing academic performance, improving instructional efficiency, or predicting negative mental health outcomes, such as anxiety, depression, and psychological distress. As a result, relatively little empirical attention has been directed toward positive psychological constructs, particularly psychological flourishing, which serves as a comprehensive indicator of students' optimal functioning and well-being within AI-supported educational environments.

Similarly, research on AI and sustainable development in higher education has largely focused on institutional or technological perspectives, emphasizing areas such as resource optimization, smart campus systems, and administrative efficiency. Far fewer studies have examined sustainable development from the students' perspective, particularly in terms of how engagement with AI applications may influence students' sustainability-related attitudes, behaviors, and individual developmental orientations.

More importantly, the existing literature has rarely examined the integrated predictive relationships among AI application use, psychological flourishing, and sustainable development within a single empirical framework. Most prior studies have investigated these variables in isolation or through simple bivariate associations, without assessing the relative predictive contribution of AI application use in explaining variations in both psychological and sustainability-related outcomes simultaneously.

Furthermore, there is a notable lack of empirical research conducted within the Arab higher education context, despite the distinctive cultural, educational, and technological factors that may influence patterns of AI use and their associated psychological and developmental outcomes. In addition, few studies have systematically examined gender-based differences in AI usage, psychological flourishing, and sustainable development within integrated analytical frameworks.

Considering these gaps, the present study aims to address this deficiency by examining the predictive role of AI application use in both psychological flourishing and sustainable development among university students, while also exploring the interrelationships among these variables and potential gender differences. By employing a quantitative, integrative approach, the study seeks to make both theoretical and empirical contributions to the literature on AI in higher education, while providing evidence-based insights to guide the responsible and psychologically sustainable integration of AI technologies within university contexts.

Research significance

The rationale for this study stems from the unique sociocultural characteristics of Egyptian society, which are likely to influence psychological processes in ways that are not fully captured by findings derived from Western contexts. Egypt is generally marked by collectivistic orientations, strong familial bonds, and a pronounced emphasis on social harmony, all of which may shape how individuals perceive, manage, and express psychological distress and well-being.

In contrast to individualistic cultures that prioritize autonomy and self-reliant coping strategies, individuals within the Egyptian context often draw more extensively on interpersonal relationships, family expectations, and culturally embedded coping resources, including religious and spiritual practices. Such contextual influences are expected to play a meaningful role in shaping the associations among the psychological variables examined in this study.

From this perspective, it is reasonable to assume that both the strength and the nature of relationships among the selected variables may differ from those reported in Western samples. Certain constructions, for instance, may operate as socially grounded processes rather than solely intrapersonal ones, thereby influencing how they relate to psychological outcomes.

Although international research on these variables has expanded in recent years, empirical evidence from Arab and Middle Eastern contexts remains relatively scarce. The present study therefore aims to address this

gap by offering culturally informed empirical findings from an Egyptian sample, contributing to the cross-cultural examination of existing theoretical models and supporting their broader applicability beyond Western populations.

Research hypotheses

Based on the theoretical framework and previous empirical studies addressing artificial intelligence applications, psychological flourishing, and sustainable development, the present study proposes the following hypotheses:

H1 *There are statistically significant differences among university students in the use of artificial intelligence applications, psychological flourishing, and sustainable development according to gender.*
Rationale: Previous research indicates that gender-related differences may be observed in patterns of technology use, indicators of psychological well-being, and perceptions of sustainability. Variations in socialization processes, along with differences in access to and engagement with digital technologies, may help explain how male and female students differ in their interactions with artificial intelligence applications, as well as in their experiences of psychological flourishing and sustainable development.

H2 *There is a statistically significant correlational relationship among the use of artificial intelligence applications, psychological flourishing, and sustainable development among the study sample.*
Rationale: Existing literature suggests that engagement with advanced technologies, including artificial intelligence applications, is associated with richer learning experiences, improved adaptive functioning, and better well-being outcomes. Moreover, psychological flourishing has been shown to relate to more positive orientations toward sustainable development, indicating that these constructs may be meaningfully interconnected within the university setting.

H3 *The use of artificial intelligence applications significantly predicts psychological flourishing among university students.*
Rationale: Prior research has demonstrated that the effective use of digital and intelligent technologies is linked to higher levels of engagement, perceived competence, and personal development, which represent key dimensions of psychological flourishing. Based on this evidence, the use of artificial intelligence applications is expected to serve as a significant statistical predictor of individual differences in students' psychological flourishing. This expectation is examined within a correlational framework and should not be interpreted as evidence of a causal relationship.

H4 *The use of artificial intelligence applications significantly predicts sustainable development among university students.*
Rationale: Artificial intelligence applications are increasingly recognized for their role in fostering skills, awareness, and behaviors that support sustainable development goals. Students who actively utilize these tools may demonstrate greater engagement with sustainability-related knowledge and practices, suggesting that AI use could serve as a significant predictor of sustainable development indicators within the study population.

It should be emphasized that the term "predict" is used strictly in its statistical sense, in line with the correlational design of this study, and does not imply any causal relationship.

Method

Research design

This research adopts a descriptive methodology, encompassing both correlational and comparative approaches.

Population

The study population comprises of university students across diverse academic disciplines and levels who utilize AI applications.

Participants

The study sample comprised university students from Fayoum University Students the Total Sample consisted of 340 students (150 for the validation & 190 for the main sample), encompassing a range of academic disciplines and study levels. Participants were recruited using a voluntary sampling method, a common approach in educational and psychological research involving university populations.

The sample size is considered adequate for the current correlational study, as it surpasses commonly recommended minimum thresholds for detecting medium-sized effects in social and behavioral research. It was also sufficient to conduct the planned statistical analyses, including correlation and regression, with acceptable statistical power.

Although participation was voluntary rather than encompassing the entire population, the response rate aligns with typical levels reported in survey-based studies involving university students. Therefore, the sample size is deemed appropriate for addressing the study objectives, while caution is advised when generalizing findings beyond the selected population.

The sample

The study sample consisted of two distinct groups, as follows:

(a) The psychometric validation sample for the study instruments:

This sample included 150 students from various academic disciplines at Fayoum University, comprising 70 male and 80 female students, their ages ranged from 20 to 25 years, with a mean age of 23.35 years and a standard deviation of 2.33 years (Table 1). This sample was used to verify validity and reliability of the instruments.

(b) Main study sample:

The main sample consisted of 190 students from the Fayoum University, with ages ranging from 20 to 25 years. The mean age was 22.54 years, with a standard deviation of 3.22 years. The following table presents the demographic characteristics of the study sample:

The demographic data indicate that most participants in the study were female, which may reflect the actual distribution within the involved academic programs or suggest a greater willingness among females to participate in psychological research compared to males. This imbalance in representation is an important factor to consider when interpreting the subsequent findings, given the potential associations between the psychological variables under investigation and gender-related differences.

Regarding academic major, the data reveal substantial diversity in the participants' disciplinary backgrounds, with psychology and sociology students comprising the largest proportion of the sample. This diversity offers notable research value, as it allows for the examination of potential differences across academic fields in the studied variables and enhances the generalizability of the findings across a broad range of university majors. At the same time, the high representation of students from the social sciences may indicate a greater interest within this group in participating in research related to psychological and behavioral phenomena.

With respect to marital status, the results show that most participants were single- a pattern expected in university-based studies given the typical age range of the student population. This demographic characteristic may influence certain psychological variables, such as stress, social support, and perceived well-being, making it necessary to consider it as a control variable in subsequent analyses.

The data also indicate that nearly half of the participants were unemployed. This distribution may contribute to understanding potential differences in psychological stress levels or life experiences associated with various employment conditions, particularly in studies addressing mental health, sustainability, or quality of life.

Overall, these characteristics suggest that the sample is diverse in terms of academic background and employment status, yet it is more heavily represented by females and unmarried individuals. This pattern should be considered when interpreting the study's findings or when assessing the extent to which the results may be generalized to other university populations.

Table 1 Demographic characteristics of the study sample ($N = 190$)

Variable	Category	*N*	%
Gender	Male	81	42.63%
	Female	109	57.37%
Academic major	Psychology	110	57.9%
	Sociology	40	21.1%
	Computer Science	11	5.8%
	Medicine	19	10%
	Engineering	10	5.3%
Marital status	Single	140	73.7%
	Married	40	21.1%
	Divorced	10	5.2%
Employment	Unemployed	145	76.3%
	Employed	45	23.7%

Instruments

Primary data collection questionnaire

his questionnaire was designed to collect basic demographic and background information about the sample to describe its characteristics. It included items on age, gender, academic major, marital status, and employment status. This questionnaire does not have a total score.

Artificial intelligence applications usage questionnaire

The AI Applications Usage Questionnaire is an effective tool for assessing the extent to which students rely on artificial intelligence in their academic and daily lives. The questionnaire which prepared by researchers consists of 11 items, each measuring a specific aspect of AI usage, responses to each item are recorded using a five-point Likert scale (Strongly agree = 5 points, agree = 4 points, neutral = 3 points, disagree = 2 points, strongly disagree = 1 point). Thus, the total score of the questionnaire ranges from 11 to 55 points. The psychometric properties of the questionnaire items were verified in terms of validity and reliability, as detailed below.

Validity: it was examined using exploratory factor analysis (EFA) due to the novelty of the scale. The EFA was conducted on the psychometric validation sample, which included 150 respondents like the main study sample in their demographic characteristics.

Sample adequacy was confirmed using the Kaiser-Meyer-Olkin (KMO) measure, which yielded a value of 0.887, indicating excellent adequacy and exceeding the minimum required value of 0.5. The Bartlett's test of sphericity produced a value of 1237.68, which was statistically significant at $p < .001$, reflecting strong factorability and overall model fit.

The EFA was performed using the Statistical Package for the Social Sciences (SPSS), applying Hotelling's principal component method with Varimax orthogonal rotation to examine the factorial structure of the scale. A factor was considered meaningful if it had at least three items loading on it and an eigenvalue greater than one.

The results of the EFA revealed three primary dimensions for the scale after Varimax rotation. The communalities for all items ranged between 0.645 and 0.865, indicating strong item-factor alignment. The total variance explained by the scale was 74.21%, a high and satisfactory value that demonstrates the scale's consistency and the strength of its items in representing the extracted factors.

Furthermore, the eigenvalue for the extracted factors reached 9.7, and all 11 items of the scale loaded significantly on the three identified dimensions. The factor structure and item loadings confirm the construct validity of the scale. The exploratory factor analysis revealed three distinct factors for the scale, as follows:

The Frist Factor consisted of four items, with factor loadings ranging from 0.775 to 0.843 Its eigenvalue was 5.61, accounting for 34.41% of the total variance. This factor was labeled "Use of Artificial Intelligence Applications in Daily Life."

The Second Factor consisted of three items, with factor loadings ranging from 0.723 to 0.778. Its eigenvalue was 2.81, accounting for 25.71% of the total variance. This factor was labeled "Use of Artificial Intelligence in Learning and Work."

The Third Factor consisted of four items, with factor loadings ranging from 0.465 to 0.731. Its eigenvalue was 2.25, accounting for 14.09% of the total variance. This factor was labeled "Use of Artificial Intelligence in Addressing Future Challenges. "These results collectively indicate the construct validity of the scale.

Reliability: Internal consistency was assessed using both Cronbach's alpha and McDonald's omega coefficients. Cronbach's alpha values were 0.785 for the first factor, 0.771 for the second factor, 0.817 for the third factor, and 0.843 for the total scale, indicating high internal consistency across both subdimensions and the overall scale. Similarly, McDonald's omega coefficients further supported the scale's reliability, with $\omega = 0.778$ for Factor 1, $\omega = 0.744$ for Factor 2, $\omega = 0.857$ for Factor 3, and $\omega = 0.874$ for the total scale. These results confirm that the scale is a reliable instrument for assessing university students' use of AI applications across the three identified dimensions.

Psychological flourishing scale (Prepared by Diener et al. 2010) (Arabic Adaptation by El-Wakeel & Basha 2024)

The Psychological Flourishing Scale was developed based on contemporary theories of well-being, encompassing both psychological and social wellness. The scale aims to assess overall flourishing, or positive functioning, in a concise and user-friendly format, minimizing time and effort required for administration.

The scale consists of 8 items, covering a broad spectrum of individual functioning, including (Competence & efficacy, Self-acceptance, Meaning, purpose Engagement and interest, Optimism, Close and supportive relationships, Contribution to the well-being and happiness of others, &Respect for others.

By integrating items related to social relationships (supportive and close connections, contributing to others' happiness, respect for others) and personal development (living a purposeful and meaningful life, active engagement, self-esteem, optimism, and perceived competence), the scale evaluates the key dimensions of social and psychological functioning as perceived by the individual.

Originally named "Psychological Well-Being", the scale's title was revised to "Psychological Flourishing" to more accurately reflect its broader content, which extends beyond traditional psychological well-being. Responses are rated on a seven-point Likert scale ranging from 1 (strongly disagree) to 7 (strongly agree). Total scores range from 8 to 56, with higher scores indicating a more positive self-perception across important domains of functioning [26].

In the Arab context, El-Wakeel and Basha [26] validated the psychometric properties of the scale across Egypt, Saudi Arabia, and Morocco, demonstrating high levels of validity and reliability, confirming its appropriateness for use in Arabic-speaking populations.

The reliability of the scale was verified using Cronbach's alpha for the pilot sample. The alpha coefficient for the overall scale was 0.879, while the alpha values for the subdimensions ranged from 0.742 to 0.821, indicating a high level of internal consistency. Additionally, McDonald's omega was employed to assess the consistency across the three subdimensions, yielding an omega value of 0.867 for the total scale, which reflects a high degree of reliability.

Sustainable development scale

This scale which prepared by researchers comprises three primary dimensions and consists of 17 items rated on a five-point Likert scale: *Strongly Agree* (5 points), *Agree* (4 points), *Neutral* (3 points), *Disagree* (2 points), and *Strongly Disagree* (1 point). Accordingly, the total score

for the scale ranges from 17 to 85 points. The psychometric adequacy of the scale items was established through the assessment of both validity and reliability, as detailed below.

Validity: It was established by employing exploratory factor validity, given the novelty of the instrument. Exploratory Factor Analysis (EFA) was conducted on the psychometric calibration sample, which consisted of 150 respondents who were comparable to the main study sample in their demographic characteristics.

Sample adequacy was verified using the Kaiser–Meyer–Olkin (KMO) measure of sampling adequacy, which yielded a value of 0.832, indicating excellent suitability and exceeding the minimum acceptable threshold of 0.50. In addition, Bartlett's Test of Sphericity produced a value of 1514.13, which was statistically significant at the 0.001 level, reflecting strong factorability and supporting the appropriateness of conducting EFA.

The EFA was performed using the Statistical Package for the Social Sciences (SPSS) with Hotelling's Principal Components extraction method and orthogonal Varimax rotation (Kaiser normalization) to examine the factor structure of the scale. Extraction criteria required that each factor include at least three items and that the eigenvalue be equal to or greater than 1.00.

Results revealed a clear three-factor solution after Varimax rotation. Communality values for all items ranged between 0.684 and 0.865, indicating strong shared variance among items.

The total explained variance of the scale reached 54.7% which is considered high and demonstrates the robustness and coherence of the items with their corresponding extracted factors. The overall eigenvalue for the scale was 12.7% further supporting the construct validity of the instrument. The factorial structure of the scale was as follows:

The first factor included 8 items with factor loadings ranging from 0.687 to 0.776 the eigenvalue was 7.87 accounting for 32.14% of the variance.

This factor was labeled "*Artificial Intelligence as a Catalyst for Sustainable Development*."

The second factor included 5 items with factor loadings ranging from 0.616 to 0.807. Its eigenvalue was 2.78, accounting for 15.26% of the variance. This factor was labeled *"Artificial Intelligence & Socioeconomic Development."*

The third factor included 4 items with factor loadings ranging from 0.525 to 0.679. Its eigenvalue was 1.96, accounting for 7.3% of the variance. This factor was labeled "Artificial Intelligence & Environmental Sustainability." Collectively, these results provide strong evidence for the factorial validity of the scale.

Reliability: Reliability was assessed using Cronbach's alpha for the total scale and its subdimensions based on the psychometric calibration sample. Results showed that the alpha coefficients for the three factors were 0.835, 0.811, and 0.865, respectively. The Cronbach's alpha for the total scale score was 0.862. All alpha values for both the subscales and the overall instrument were high, indicating excellent internal consistency and demonstrating the strong reliability of the scale.

Field work

Data collection for the current study was needed for three months, beginning in April 2025 and concluding at the end of June 2025. It took each student between 30 and forty minutes to complete the data gathering tools. The students who agreed to participate in the study were only made aware of its goal prior to any data being gathered.

Data analysis

The collected data were analysed using SPSS (Version 23) and AMOS for structural validation. The following analyses were conducted:

1. *Descriptive statistics*: To summarize demographic characteristics and compute mean scores, standard deviations, and frequency distributions for all variables.
2. *Comparative analysis*: Independent samples t-tests and ANOVA were performed to examine differences in AI usage, psychological flourishing, and sustainable development across gender, academic major, and other demographic variables.
3. *Correlational analysis*: Pearson correlation coefficients were calculated to assess the strength and direction of relationships between AI usage, psychological flourishing, and sustainable development.
4. *Predictive analysis*: Multiple regression analyses were conducted to examine whether AI usage could significantly predict psychological flourishing and sustainable development, controlling for relevant demographic variables.

All statistical tests were interpreted at a significance level of $p < .05$, and assumptions for each analysis were checked, including normality, homoscedasticity, and multicollinearity. Factor structures of all scales were verified via exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) as appropriate.

Results

The first hypothesis Stated that "*there are statistically significant differences among university students in the use of artificial intelligence applications, psychological flourishing, & sustainable development according to gender*" To examine this hypothesis, independent-samples *t*-tests

Table 2 Differences between male and female students in the use of artificial intelligence applications, psychological flourishing, & sustainable development

Variables	Males ($n=81$)		Females ($n=109$)		t value	Significance
	Mean	SD	Mean	SD		
Using AI applications	63.55	5.10	57.68	5.79	7.25	0.001
Psychological flourishing	74.94	6.22	70.13	7.54	4.67	0.001
Sustainable development	38.15	4.69	35.27	4.45	4.30	0.001

Table 3 Relation between using of artificial intelligence applications, psychological flourishing, and sustainable development among the study sample

Variables	AI applications	Psychological flourishing	Sustainable development
AI applications	1	0.425**	0.598**
Psychological flourishing	0.425**	1	0.614**
Sustainable development	**0.598****	**0.614****	**1**

**Correlation is significant at the 0.01 level (two-tailed)

Table 4 The role of AI applications in predicting psychological flourishing among the study sample N = 190

Independent variable	Dependent variable	*R*	R^2	Unstandardized beta (B)	Standardized beta (β)	F value (sig.)	t value (sig.)	Constant
AI applications	Flourishing	0.313	0.098	0.313	0.176	17.5**	4.18**	27.31

**Significant at the 0.01 level

were conducted to identify differences between male and female students across the study variables: use of artificial intelligence applications, psychological flourishing, and sustainable development (Table 2). The results are presented in the following table:

The results indicate that:

- There are statistically significant differences at the 0.001 significance level between males and females in Using Artificial Intelligence Applications toward male students, as the mean score of males was higher than that of females.
- There are statistically significant differences at the 0.001 significance level between males and females in psychological flourishing toward male students.
- There are statistically significant differences at the 0.001 significance level between males and females in sustainable development in toward male students.

These findings support the first hypothesis, showing gender-based differences in Using AI Applications, psychological flourishing and sustainable development.

The Second hypothesis Stated that *"there is a statistically significant correlational relationship among the use of artificial intelligence applications, psychological flourishing, and sustainable development among the study sample."* To examine this hypothesis, Pearson's Product–Moment Correlation Coefficient was calculated directly from the raw scores of the participants (Table 3). The results are presented in the following table:

The results indicate statistically significant positive correlations among all three variables:

The use of artificial intelligence applications was positively correlated with psychological flourishing ($r=0{,}425$ $p<.01$), It was also strongly and positively correlated with sustainable development ($r=0{,}598$, $p<.01$). Psychological flourishing showed a strong positive correlation with sustainable development ($r=0{,}614$, $p<.01$). These findings support the hypothesis, demonstrating meaningful and statistically significant interrelationships among the study variables.

The Third Hypothesis Stated that *the use of artificial intelligence applications predicts psychological flourishing among university students*." To examine this hypothesis, simple linear regression using the Enter method was employed to determine the predictive power of the independent variable on the dependent variable (Table 4). The following table presents the results related to predicting psychological flourishing:

Interpretation of the Regression Indicators:

1. Correlation Coefficient ($r=.313$) Indicates a moderate positive correlation between the use of artificial intelligence applications and psychological flourishing. In other words, higher use of AI applications is associated with higher levels of flourishing.
2. Coefficient of Determination ($R^2=0.098$) Shows that AI application use explains 9.8% of the variance in psychological flourishing. This is an acceptable level in psychological and social sciences, where outcomes are typically influenced by multiple variables.
3. Unstandardized Beta ($B=0.313$) Suggests that for every one-unit increase in AI application use, the

Table 5 Role of AI applications in predicting sustainable development among the study sample N = 190

Independent variable	Dependent variable	*R*	R^2	Unstandardized Beta (B)	Standardized beta (β)	F value (sig.)	t value (sig.)	Constant
AI applications	Sustainable Development	0.777	0.603	1.06	0.777	245.78**	15.68**	23.87

**Significant at the 0.01 level

psychological flourishing score increases by 0.313 units, based on the scale's measurement metric.

4. Standardized Beta (β = 0.176) Reflects the relative strength of the independent variable's effect. Here, the effect size is considered small to moderate.
5. F value = 17.5 ($p < .01$) Indicates that the regression model is statistically significant. Thus, AI application use is a valid predictor of psychological flourishing.
6. *t* value = 4.18 ($p < .01$) Confirms that the regression coefficient (B) is significantly different from zero, meaning the effect of AI application use on flourishing is statistically significant and not due to chance.

$$\text{Predictive Equation Flourishing} = 27.31 + 0.313 \times (\text{AI Applications})$$

This equation demonstrates that AI application use has a statistically meaningful and positive predictive effect on psychological flourishing among university students.

The fourth Hypothesis Stated that *the use of artificial intelligence applications predicts sustainable development among university students."* To examine this hypothesis, simple linear regression using the Enter method was employed to determine the predictive power of the independent variable on the dependent variable (Table 5). The following table presents the results related to predicting psychological flourishing:

Interpretation of Regression Indicators:

1. Correlation Coefficient ($r = .777$) This value indicates a very strong positive correlation between the use of artificial intelligence applications and sustainable development. Students who report higher levels of AI application use tend to exhibit substantially higher levels of perceived or achieved sustainable development.
2. Coefficient of Determination ($R^2 = 0.603$) AI application use explains 60.2% of the variance in sustainable development scores. This is a remarkably high proportion in the social sciences, reflecting the powerful predictive capacity of the model.
3. Unstandardized Beta (B = 1.06) For every one-unit increase in AI application use, sustainable development scores increase by 1.06 units, according to the measurement scale.
4. Standardized Beta (β = 0.777) This value reflects a very strong relative effect. Such a high standardized coefficient is uncommon in psychological and educational research, underscoring the substantial influence of AI application use on sustainable development.
5. F value = 245.78 ($p< .01$) Indicates that the overall regression model is highly statistically significant, confirming that the independent variable explains meaningful variance in the dependent variable.
6. *t* value = 15.68 ($p< .01$) Demonstrates that the regression coefficient (B) is highly significant statistically, providing strong evidence that the effect of AI application use on sustainable development is real and not attributable to random variation.

Overall, the findings reveal that the use of artificial intelligence applications is a strong and influential predictor of sustainable development among university students, explaining more than 60% of the variance in this construct. This highlights the essential role of integrating AI technologies in educational contexts to advance sustainability goals.

$$\text{Predictive Equation: Sustainable Development} = 23.87 + 1.06(\text{AI Applications})$$

This equation reflects the substantial and statistically robust predictive contribution of AI application use to sustainable development outcomes.

Discussion

The present study aimed to examine how the use of artificial intelligence applications can contribute to enhancing the quality of university life across two core dimensions: psychological flourishing and the achievement of sustainable development goals among students. Building on this overarching objective, the research focused on exploring the nature of the correlational relationships among the three variables and assessing the strength and impact of each on the others. This approach allows for a comprehensive understanding of the role that intelligent technologies play in supporting mental health and promoting sustainable behaviors and practices within the university environment. These objectives provided the foundational framework for interpreting the study's findings, discussing their implications, and analyzing the extent to which

artificial intelligence tools contribute to psychological well-being and social responsibility among university students.

The results of the first hypothesis indicated that there were statistically significant differences between male and female students in the using AI applications, psychological flourishing and sustainable development in favor of male students. Males reported higher levels of Using AI, psychological flourishing and sustainable development. This outcome can be interpreted within several theoretical frameworks.

These results suggest equitable use of artificial intelligence across genders, indicating that AI has become an integral part of the modern educational environment for both male and female students. The use of intelligent applications is no longer associated with gender but rather with the university environment and the integration of digital tools within it. Gender parity in AI usage may be attributed to the growing reliance on digital technologies across disciplines, where access is broadly available to all students. With the widespread availability and ease of access to intelligent tools, AI usage has become a fundamental component of the academic environment for both male and female students.

This finding aligns with the results of Nguyen et al. [2], who reported that the prevalence of AI technology use among university students is converging regardless of gender, as these technologies are increasingly integrated with modern educational and research tools. Similarly, Velastegui Hernández et al. [27] emphasized that the impact of AI on mental health and psychological flourishing is less dependent on gender and more on how students engage with and utilize these technologies. The effect of AI on psychological well-being and flourishing appears comparable across genders, with differences primarily determined by usage patterns rather than gender itself.

The observed advantage of male students in psychological flourishing and sustainable development may be associated with several factors:

Social roles: Males are often more likely to adopt independent coping strategies, which may contribute to higher levels of psychological flourishing compared to females.

The present findings showed that male students reported higher levels of psychological flourishing than their female counterparts, consistent with Zafar [9], who found that males are more likely to employ positive coping strategies that enhance well-being. Additionally, Dekker et al. [28] noted that male students are more inclined to leverage AI applications to improve academic performance, which in turn enhances their psychological flourishing.

- Academic and social pressures: Some studies suggest that female students experience higher levels of anxiety regarding academic performance and future career prospects, which may negatively affect their sense of psychological flourishing.
- Academic specialization: Given that most of the sample were enrolled in social sciences programs, which may foster a more analytical and critical perspective on social realities, this may influence female students' perceptions of sustainability and psychological well-being differently from male students.

Regarding sustainable development, Chemlal and Azzouazi [22] reported that males are more likely to participate in technology- and environment-related activities associated with sustainability. This may explain the observed gender differences in this domain, as research indicates that males tend to adopt more practical and applied approaches to technology, which supports sustainable behaviors.

Results of the second hypothesis revealed the presence of statistically significant positive correlations at the 0.01 level among the study variables, namely the use of artificial intelligence (AI) applications, psychological flourishing, and sustainable development within the study sample. These findings indicate the potential of AI application use to predict both psychological flourishing and sustainable development among students, suggesting that increased engagement with AI applications is associated with higher levels of psychological well-being and sustainable practices. Several observations can be derived from these results:

Positive impact of AI on psychological flourishing

This effect can be attributed to the capacity of AI applications to offer personalized academic and professional support, helping students develop their skills, alleviate stress, and enhance self-confidence. AI systems, including chatbots and virtual assistants, provide students with immediate psychological and emotional support, thereby promoting well-being. Additionally, AI tools deliver tailored academic assistance that mitigates psychological pressure and reinforces self-efficacy, while on-demand guidance from chatbots and virtual assistants further supports students' learning and personal development.

These findings align with Bhattacharjee [1], who reported that the use of AI for psychological support through chatbots and virtual assistants significantly enhances students' sense of well-being. Similarly, Miotto et al. [8] demonstrated that AI can predict psychological conditions such as depression and stress through big data analytics, facilitating early intervention and promoting mental health. Conversely, Ghosh [19]. cautioned

that AI applications in mental health may have negative consequences if not integrated ethically and responsibly, potentially fostering overreliance on technological solutions at the expense of traditional human support.

Positive impact of AI on sustainable development

Artificial intelligence supports sustainable development by providing intelligent solutions for time management, resource optimization, and increased academic and professional efficiency. AI tools further encourage more sustainable educational practices, such as facilitating remote learning and enabling the customization of curricula to meet individual student needs, thereby fostering sustainability within the university environment. In addition, AI applications help streamline the use of educational resources, aligning closely with sustainability-oriented objectives in higher education.

The results indicated that AI was more strongly associated with sustainable development than with psychological flourishing. This aligns with Khan et al. [17], who emphasized that AI is a key instrument for achieving sustainability in higher education by improving resource efficiency and delivering personalized education tailored to the needs of students and society. Furthermore, Abou et al. [11] supported this conclusion, highlighting the role of AI in transforming universities into "smart universities" capable of advancing sustainable development.

Results of the third hypothesis indicated that using artificial intelligence (AI) applications is a statistically significant predictor of students' psychological flourishing, although the explanatory power was limited to 9.8%. This suggests the importance of investigating additional variables, which is theoretically consistent, as psychological flourishing is influenced by multiple factors-including personality traits, social support, and positive thinking. Psychological well-being is shaped by deep internal factors that cannot be fully predicted by technology alone, meaning that the impact of AI is partial rather than comprehensive. This finding aligns with Mumenin et al. [6], who demonstrated that AI could predict psychological conditions such as anxiety and depression using machine learning algorithms that analyze demographic variables, lifestyle habits, and academic performance. Similarly, Tian and Yi [10] confirmed that AI-based analysis of mental health data can provide advanced psychological support systems, contributing to reduced stress and academic pressure.

Results of the fourth hypothesis revealed that AI applications significantly predict sustainable development within the university community, with an explanatory power of 60%, indicating a strong predictive role. This suggests that AI applications play a central and substantial role in enhancing sustainable development among university students, supporting the integration of these technologies into educational environments as an effective strategy for achieving contemporary developmental, environmental, and social goals. These results are consistent with Ferk Savec and Jedrinović [12], who highlighted that AI applications play a pivotal role in promoting sustainability within higher education institutions by improving resource management and allocation efficiency. Similarly, Fošner [20] found that AI helps students develop sustainable behaviors by providing data-driven recommendations and analyses, fostering the adoption of environmentally friendly practices. Sustainable development, in this context, depends on measurable behaviors such as resource consumption, time management, and efficiency.

Based on these findings, artificial intelligence can be conceptualized as a dual-dimensional catalyst: firstly, by promoting students' psychological well-being and self-efficacy, and secondly, by fostering sustainable cognition and behaviors. This connection between the study objectives and observed results provides a solid foundation for discussing how AI technologies can be effectively integrated into curricula and university activities, generating a comprehensive positive impact that aligns with the psychological, social, and developmental goals of higher education institutions.

Cultural contextualization of the findings

The interpretation of the present findings should be considered within the broader cultural context in which the data were collected. Cultural factors are known to influence not only the nature of psychological constructs themselves but also how individuals respond to self-report measures assessing these constructions.

In collectivistic contexts, such as Egypt and the wider Arab world, individuals often place a strong emphasis on social harmony, group expectations, and socially desirable responses. This orientation may affect how participants perceive, and report constructs such as psychological flourishing and sustainable development, which are frequently conceptualized in Western literature as predominantly individual-centered experiences.

Perceptions and uses of artificial intelligence applications may also vary across cultural settings. In some non-Western contexts, AI technologies may be regarded primarily as practical tools for academic performance and efficiency, rather than as instruments for personal growth or autonomy. Such perspectives could influence response patterns on related measures.

These cultural dynamics may partly account for differences in the strength or nature of the relationships observed in this study compared to those reported in Western samples. The findings underscore the importance of cultural sensitivity when interpreting scale-based data and suggest that cross-cultural variations in

response styles and construct interpretations should be carefully considered.

Future research utilizing cross-cultural comparative designs and mixed-method approaches could provide deeper insights into how cultural contexts shape both the experience and measurement of artificial intelligence use, psychological flourishing, and sustainable development.

Conclusion

The present study provides empirical evidence highlighting the multifaceted role of artificial intelligence (AI) applications in enhancing university students' psychological flourishing and sustainable development.

The findings indicate that while AI usage is equitable across genders, male students reported higher levels of psychological flourishing and sustainable development, suggesting that differences in social roles, coping strategies, academic pressures, and engagement patterns may influence these outcomes.

Importantly, the study demonstrated significant positive correlations among AI application usage, psychological flourishing, and sustainable development, confirming the predictive potential of AI in fostering both mental well-being and sustainable practices. AI applications contribute to psychological flourishing by offering personalized academic and emotional support, facilitating stress reduction, enhancing self-efficacy, and promoting adaptive coping strategies. Simultaneously, AI significantly advances sustainable development within the university context by optimizing resource utilization, supporting remote and individualized learning, and encouraging environmentally conscious behaviors.

Notably, the predictive power of AI for sustainable development (60%) was substantially stronger than for psychological flourishing (9.8%), indicating that while AI is a powerful tool for promoting sustainability-related behaviors and practices, its impact on psychological well-being is partial and likely mediated by other individual and contextual factors, such as personality traits, social support, and intrinsic motivation. These findings underscore the importance of integrating AI technologies thoughtfully into educational curricula and university practices, balancing technological interventions with human-centered support systems.

In conclusion, AI can be conceptualized as a dual-dimensional catalyst within higher education: first, by enhancing students' psychological well-being, self-efficacy, and coping capacities, and second, by fostering sustainable cognition, behaviors, and practices. The integration of AI applications into university environments offers a strategic pathway for promoting both mental health and sustainable development, aligning with the broader objectives of contemporary higher education institutions to cultivate socially responsible, psychologically resilient, and environmentally aware graduates.

Given the correlational design of this study, the results should be understood reflecting.

Implications

The findings of the present study have several important implications for educational practice, psychological well-being initiatives, and sustainable development efforts within university settings. The observed relationships among the use of artificial intelligence applications, psychological flourishing, and sustainable development indicate that these constructs are meaningfully interconnected and deserve integrated attention in higher education contexts.

From an educational standpoint, the results underscore the potential benefits of thoughtfully incorporating artificial intelligence applications into university learning environments. When implemented effectively, such tools may enhance student engagement, support adaptive learning experiences, and foster competencies that contribute not only to academic success but also to broader developmental objectives.

With respect to psychological well-being, the association between AI use and psychological flourishing suggests that technology-supported learning environments may promote positive psychological experiences, including feelings of competence, personal growth, and purpose. University counseling services and student support programs may therefore consider integrating digital and intelligent technologies into initiatives aimed at enhancing student flourishing.

Additionally, the relationship between AI applications and sustainable development highlights the role of technological literacy in promoting sustainability-related knowledge, awareness, and behaviors among students. Higher education institutions may benefit from embedding sustainability-oriented content and ethical considerations into technology-enhanced curricula to reinforce these outcomes.

It is important to emphasize that these implications are based on correlational findings and should be interpreted as indicative rather than causal. Nonetheless, the results offer a valuable empirical foundation for future intervention-based and longitudinal research aimed at examining how artificial intelligence applications can be strategically leveraged to support both psychological flourishing and sustainable development within higher education contexts.

The findings indicate that the variables under investigation are meaningfully associated within the studied population, underscoring their potential significance for both clinical and preventive applications. Nevertheless, these implications should be considered with caution, as the

correlational nature of the data does not support causal interpretations.

Recommendations

Based on the findings of the present study, the researchers recommend integrating artificial intelligence (AI) applications across all university programs to promote sustainable learning, with particular emphasis on training students in the positive and responsible use of these technologies to support psychological flourishing and reduce academic anxiety. The study further suggests the development of university-based psychological chatbots and AI-driven counseling and guidance programs to provide immediate support, enhance students' self-confidence, and foster motivation.

In addition, the recommendations emphasize the importance of linking AI application use to sustainability initiatives within the university campus and leveraging AI-based predictive analytics for the efficient management of energy and institutional resources. The study also underscores the necessity of establishing an ethical framework for AI implementation that safeguards students' mental health, alongside the development of national standards to regulate AI use in higher education. Such measures would facilitate the achievement of Sustainable Development Goals while ensuring a balanced consideration of academic and psychological benefits alongside ethical and sustainability concerns.

Limitations of the study

This study has several limitations as follows:

1. Given the correlational design of this study, the results should be understood as reflecting patterns of association rather than causal effects. Although statistically significant relationships were observed among the variables examined, the study design does not allow for conclusions about causal direction or underlying mechanisms. Consequently, the findings are interpreted as highlighting meaningful associations that may offer valuable insights for future research and applied practice, rather than as evidence of direct cause-and-effect relationships. Further research employing longitudinal or experimental designs is recommended to more clearly examine potential causal pathways underlying the observed associations.
2. While the sample reflected diverse student characteristics, future research is recommended to employ probability sampling methods and multi-institutional designs to improve representativeness and enhance the generalizability of findings.
3. Future research may benefit from larger samples and higher participation rates to further strengthen the generalizability of the findings.
4. Correlational design allows for examining predictive relationships but does not establish causality.
5. The results reflect specific AI applications used by the participants, without experimental comparison across different tools.
6. Finally, external factors such as social support, academic stress, or prior mental health conditions were not fully controlled and may have influenced the outcomes.

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Author contributions

First Author: Contributed to the conceptualization of the study and formulation of the research problem; designed the research methodology; developed the study instruments; supervised data collection; conducted the statistical analyses; and drafted the initial version of the manuscript. Second Author: Contributed to the development of the theoretical framework and the review of the relevant literature; participated in the interpretation and discussion of the findings considering prior studies and psychological theories; and provided scholarly review and critical revision of the initial manuscript. Third Author: Contributed to the overall academic supervision of the study; ensured compliance with scientific publication standards and APA style (7th edition); and reviewed and scientifically validated the study results. Fourth Author: Contributed to the overall academic supervision of the study; reviewed and refined the scientific and linguistic formulation of the manuscript; ensured compliance with scientific publication standards and APA style (7th edition); and reviewed and scientifically validated the study results. All authors confirm their substantive contributions to the study, their review and approval of the final version of the manuscript, and their agreement to submit it for publication.

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Data availability

The authors confirm that the data supporting the findings of this study are available within the article.

Declarations

Ethics approval and consent to participate

This study was conducted in accordance with internationally recognized ethical standards. Prior to data collection, participants were verbally informed about the study objectives, the voluntary nature of participation, and their right to withdraw at any time without consequences. Confidentiality and anonymity were strictly maintained, and no personally identifiable information was collected. The study received institutional approval from the (IRB) at Faculty of Arts, Fayoum University (Approval No. 25.4.11).

Competing interests

The authors declare no competing interests.

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