Promoting Student Success with Neutrosophic Sets: Artificial Intelligence and Student Engagement in Higher Education Context

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Abstract

Several higher education institutions recommended active learning many decades ago. In many fields, artificial intelligence (AI) has turned out to be a dominant aspect of people's lives. One of the fields that welcome AI is education. AI can play a crucial role in active learning, which is a teaching method that encourages students to take an active role in their learning process. Active learning can involve a wide range of activities, such as problem-solving, group discussions, and self-reflection. This quantitative research paper aims to explore students' engagement and perceptions of patterns of embracing AI tools and their relationship to student learning outcomes. A diverse sample of 355 students from a highly reputable university in the United Arab Emirates participated in the research study (UAE). Descriptive Analysis and Correlation Coefficient were used to achieve the paper's objectives. Findings uncovered students' high engagement level in classroom activities, and they perceived AI tools as useful and effortless, which promotes their engagement and attention inside classrooms. Furthermore, the results demonstrated the existence of a positive association between students' perceptions of embracing AI and student engagement in the learning environment. However, students' learning outcomes have a non-remarkable association with student engagement and their perception of AI patterns. The study's findings suggest embracing and promoting AI applications in classrooms to keep students engaged. This study's use of Neutrosophic sets offers a fresh way to approach the problem of ambiguity when evaluating students' opinions and performance in relation to AI technologies. Neutrosophic sets, a mathematical framework designed to manage uncertainty, provide a sophisticated way to understand how students' complicated interactions with AI operate. This integration promises a more comprehensive and flexible educational paradigm and is a trailblazing method of negotiating the complexities of active learning in higher education.

Keywords: Active learning; Neutrosophic Set; Artificial Intelligence; learning outcomes; higher education.

1. Introduction

Active learning is a learning context in which students are engaged by discussing, examining, and creating their learning experience. Researchers defined active learning as expressing helpful activities inside the classroom to keep students engaged while involved in the learning experience by applying problem-solving techniques, being involved in a discussion, and working individually or in groups to teach their peers [30, 33, 37]. The issue of keeping students engaged and motivated is an essential demand inside classrooms. Investigating the literature showed that when students are engaged, this promotes their learning [42]. It was revealed that students' engagement plays a significant role in improving students' poor achievement [17]. Moreover, research findings discovered that students' learning consequences and achievement are heavily influenced by students' engagement in classroom activities [15]. It was shown that integrating modern technology enriches students' learning and increases their engagement, in addition to promoting teaching practices and enhancing learning intensively [22].

Doi: https://doi.org/10.54216/IJNS.230121
Received: June 04, 2023 Revised: August 21, 2023 Accepted: November 28, 2023

At this time, the advent of innovative machinery of Artificial Intelligence (AI) has been embraced in various fields. AI implementation creates more exploring experiences and provides engagement opportunities for higher education students [43]. AI tools can be applied to encourage personalized learning and in-class activities. Many research studies [29, 32, 38] proved that components of AI can enhance students' learning outcomes, which signifies measuring students' engagement in classrooms in which AI tools are embraced and how embracing AI can promote student's learning outcomes. As active learning depends heavily on students' engagement, researchers and educators need to address all the challenges of active learning to expect effective learning outcomes. One of the primary objectives of active learning is student engagement. Since the effect of students' engagement in their learning outcomes was proven [15], thus, examining the contribution of AI in advancing students' engagement in the learning context is in demand. The current research paper aims to measure (1) students' engagement level in a learning environment in which AI is embraced (2) students' perceptions of using AI in learning (3) the relationship between students' engagement and the pattern of using AI technologies within college learners in the UAE, and (4) measuring the interrelationships between students' engagement, AI and students learning outcomes. As the research in that area in the UAE is insufficient, it is necessary to achieve this research project and discover the role of AI tools and student engagement in promoting learning outcomes. Given the diversity of the higher education population, the outcomes of the current study will participate in the formation of higher education from the standpoint of attracting more students and showing education system enhancement in the UAE.

Neutrosophic sets offer a sophisticated approach to managing complicated and ambiguous educational data, giving educators and AI systems a more thorough grasp of how to traverse the nuances of student performance. By employing neutrosophic sets to fuel AI tools, a customized approach to student engagement is made possible, accounting for a range of learning styles, preferences, and performance metrics. This all-encompassing approach aids in the improvement of teaching tactics by creating an atmosphere that supports each student's unique academic path. Higher education institutions may increase their ability to evaluate and analyze student engagement as well as customize interventions and support mechanisms for better overall performance by utilizing neutrosophic sets inside the AI framework. Additionally, the cooperation between AI and neutrosophic sets under the framework of advancing student success transcends conventional educational boundaries. The amalgamation of these advanced technologies empowers educators to create dynamic, adaptable learning environments that respond to the evolving needs of students. Neutrosophic sets offer a robust mathematical foundation to handle the uncertainties inherent in the educational landscape, providing a nuanced lens through which AI systems can interpret and respond to student engagement data. In essence, the synergy between promoting student success, AI, and neutrosophic sets paves the way for a holistic, student-centric educational paradigm that aligns with the diverse and ever-changing nature of higher education.

2. Literature Review

2.1 Student Engagement

The topic of student engagement is a critical one that provokes educators' and researchers' interest to study. Because the learning context is a complex field, it is difficult to define a common term and definition to describe students' participation in the learning process. The effort that has been made by researchers and professionals in the field introduced some conceptualization of student engagement such as the work of [12, 25, 41, 20]. Decades ago, educators presented several definitions to explain the meaning of student engagement. [20] described student engagement as "the quality of effort students themselves devote to educationally purposeful activities that contribute directly to desired outcomes" (P.3). In most cases, student engagement can be perceived as "how *involved* or *interested* students appear to be in their learning and how *connected* they are to their classes, their institutions, and each other" [4]. Moreover, student engagement was characterized as "the extent to which students are engaging in activities that higher education research has shown to be linked with high-quality learning outcomes" [25]. Furthermore, student engagement may refer to the energy and striving expressed in actions, an apparent behavior found in some indicators [9, 36]. To understand the meaning of engagement, it is necessary to understand that researchers have debated the dynamics of the construct (engagement) because the state of engagement has not been differentiated. Some researchers proposed four distinct perspectives to explain engagement: the psychological approach, which believes that engagement is an internal personalized process; the behavioral approach, which emphasizes effective teaching practices; the viewpoint of socio-cultural, which emphasizes the impact of socio-cultural context; and finally, the holistic approach, which seeks to integrate elements. The researchers defined student engagement as a "student's ability to stay connected in an e-learning environment based on the use of modern technology to facilitate the learning process" for this research project.

As the notion of student engagement has spread, researchers focused on examining it [1, 6, 14, 34] from different perspectives focusing on its impact on learning consequences. In traditional/face–to–face classrooms, student engagement is a manageable problem, however, it requires sufficient interaction. One of the benefits of student engagement is its role as a substitute for learning conditions [26]. [20] proposed that student engagement can

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Received: June 04, 2023 Revised: August 21, 2023 Accepted: November 28, 2023

predict student dropout in both high schools and colleges when discussing the role of student engagement in student sustainability. Many factors within the learning environment influence student engagement, including mutual relationships, learning activities, and the learning environment. Student social engagement within their learning environment increases the likelihood that they will channel their potential into learning.

2.2 AI Technologies and Student Learning

Retracing the history of Artificial Intelligence revealed that it first appeared a long time ago; however, tracing the roots of AI revealed that it has been in use since the early 1940s. Since the inception of AI and its application in various fields, a clear definition of AI is required. However, an exact definition of the term Artificial Intelligence has caused much confusion and is still being debated. [24] presented a set of articulated definitions to describe AI, including (1) A branch of search and study in the discipline of computer science. AI technologies rely on the advancement of computing devices capable of engaging in processes similar to the ones performed by humans like reasoning, thinking, learning, and self-reflection. (2) The process of creating machines that can perform tasks normally associated with human intelligence, such as conceptualization, learning, revising, self-reflection, and so on. (3) AI refers to a computerized extension of human intelligence that can perform tasks previously performed by mechanical tools. (4) Using a set of procedures to improve computer performance by embracing improved programming techniques. According to [27], the first AI laboratory was established by Allen Newell and Herbert Simon. AI is primarily a branch of computer science focused on realizing intelligence dynamics and developing computer structures that can perform intelligent actions [42]. With the growing use of AI applications such as Smartphones, smart home appliances, Siri, and computer games, people have more interaction opportunities with these applications, which have become a main component of our daily lives [40]. The benefits of AI applications are being extended to improve humans' daily lives, including education, through individualized teaching for students [19].

As the role of student engagement has been investigated by educators, the findings of research studies revealed a link between engaging students and increased achievement, perseverance, and student retention [25, 20]. Furthermore, it was discovered that insufficient engagement has a negative impact on student knowledge and cognitive improvement [29]. In response to the increased emphasis on student engagement and its significance in student learning, digital technologies have been identified as a critical component of engaging higher education students [5]. As the integration of technology into education promotes student learning, it is recommended to realize the connection between educational technologies and student engagement in order to improve instructional design and delivery and thus students' learning outcomes [7]. It is not an overstatement to say that technology has completely transformed the classroom and brought immense benefits to teaching techniques and the learning process. Embracing technology was recognized to participate in human development such as increasing individuals' self-regulation and self-efficacy [3]. The creative technology of AI is a comprehensive tool that allows users to reconsider different methods of integrating information, data analysis, and utilizing the outcome to make correct decisions. The wide range of AI applications facilitates daily life activities in various sectors. In education, AI handles emerging education challenges such as filling the technological gap that exists between students and instructors. Researchers reported that AI is an innovative technological aspect that fascinates many professionals to embrace, moreover, AI resources have been embraced by several individuals and professionals in the operation of their daily tasks[2, 5]. It can be difficult for both teachers and students to adjust to this exciting new reality. However, the benefits to those who embrace it are virtually limitless. On the other hand, it was found that it is not guaranteed that technology keeps students engaged [23]. Technology, like any other assistive tool, has drawbacks. [39] conducted a second-order meta-analysis spanning 40 years and discovered a weak to moderate effect on student achievement. In the learning environment, well-designed pedagogy, appropriate planning, and appropriate teaching tools are critical [11]. Furthermore, "technology can amplify great teaching, but great technology cannot replace poor teaching" [31]. Today, Artificial Intelligence is a prominent tool that has infiltrated many fields, including medicine, business, tourism, science, and education, and has an impact on people's daily lives.

3. Methodologies

3.1 Study Design

The current paper disseminates a nonexperimental study that uses a quantitative research approach to discover students' engagement level and their conceptualization of using AI technologies in a higher education learning environment, in addition to, exploring the interrelationships between students' engagement, AI, and students' learning outcomes. The researchers chose a quantitative design to examine a large sample size and confirm the findings' generalizability and study replicability. Since AI has been implemented in most of the courses, the student learning outcome is measured implicitly by calculating the overall Grade Point Average (GPA) of students. The study design proposes two factors which are perceiving AI as easy to use and AI as a useful tool, which will promote their engagement, and the more engagement, the higher the perception levels which may lead to a positive learning outcome as demonstrated in Figure 1.

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Received: June 04, 2023 Revised: August 21, 2023 Accepted: November 28, 2023

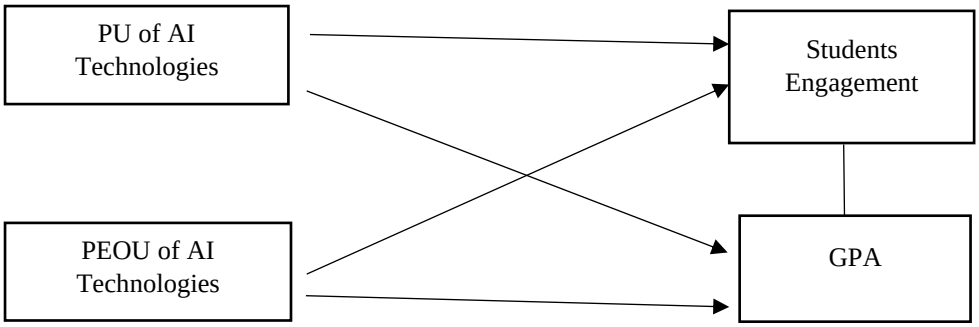

Figure 1: Study Design and Hypotheses

Embracing AI and Student Engagement using Neutrosophic Set

This study proposes implementing AI applications in teaching in a traditional learning environment to keep students engaged and concentrating. AI technologies are used for multiple purposes to enhance teaching practices and enrich learning activities in higher education such as detecting plagiarism, learning management systems, online discussion boards, transcribing class lectures, and conducting academic research, in addition to analyzing student success metrics., chatbots, which is used for enrollment and retention.

In the detailed analysis of the relationship between AI adoption and student involvement, we utilise Neutrosophic set theory to present a higher degree of mathematical complexity. Let U be the universal set of all students, A be the Neutrosophic set describing how students are embracing AI, E be the Neutrosophic set describing how students are engaging with the technology, and N be the Neutrosophic set capturing the indeterminacy in this dynamic interaction. Neutrosophic sets can be stated mathematically as:

$$A=\{x, x^{\check{}}, x^{\hat{}} \mid \text{where } x \in U\}$$

$$E=\{y, y^{\check{}}, y^{\hat{}} \mid \text{where } y \in U\}$$

$$N=\{\alpha, \alpha^{\check{}}, \alpha^{\hat{}} \mid \text{where } \alpha \in U\}$$

Here, x and z denote the truth membership, $x^{\check{}}$ and $y^{\check{}}$ denote the indeterminacy membership, and $x^{\hat{}}$ and $y^{\hat{}}$ denote the falsity membership. The Neutrosophic intersection ($\cap n$) is then employed to capture the complex amalgamation of AI embracement and student engagement with indeterminacy consideration:

$$N(A \cap nE) = \{ \min(x,y), \min(x^{\check{}},y^{\check{}}), \min(x,y) \mid x \in A, y \in E\}$$

The Neutrosophic components are included in this formulation, which permits a thorough analysis of the complex relationships between student involvement and AI adoption while taking into account the inherent uncertainties in these cognitive and behavioural processes. Furthermore, Neutrosophic entropy (*EntN*) and Neutrosophic correlation coefficients (ρ N) may be investigated in order to measure the level of indeterminacy and correlation in this complex connection, thereby improving the analytical rigor.

In delving deeper into the mathematical intricacies of Neutrosophic sets in the context of AI embracement and student engagement, let's extend our analysis by introducing Neutrosophic entropy (*EntN*) to quantify the degree of indeterminacy within each set. The Neutrosophic entropy is calculated as follows:

$$EntN(A) = -\sum \forall x \in U(T(x)\cdot\log(T(x)) + I(x)\cdot\log(I(x)) + F(x)\cdot\log(F(x)))$$

where ($T(x)$), ($I(x)$, and ($F(x)$ denote the truth, indeterminacy, and falsity membership degrees of x in Neutrosophic set A. This measure provides valuable insights into the overall uncertainty encapsulated within the sets representing AI embracement (A) and student engagement (E), enhancing our understanding of the intricate dynamics. Furthermore, to quantify the Neutrosophic correlation between AI embracement and student engagement, the Neutrosophic correlation coefficients (ρN) can be utilized. The Neutrosophic correlation coefficient is defined as:

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Received: June 04, 2023 Revised: August 21, 2023 Accepted: November 28, 2023

$$\rho_N(A,E) = \frac{\sum_{\forall x \in U} T(x)\cdot T'(x) + I(x)\cdot I'(x) + F(x)\cdot F'(x)}{\sqrt{\sum_{\forall x \in U}(T(x)+I(x)+F(x))\cdot(T'(x)+I'(x)+F'(x))}}$$

Here, (T'' (x), $I'(x)$, and $F'(x)$ denote the corresponding membership degrees in Neutrosophic set E. The Neutrosophic correlation coefficient offers a comprehensive measure of the association between the two sets, accounting for truth, indeterminacy, and falsity memberships. These additional mathematical considerations contribute to a nuanced and quantitative exploration of the Neutrosophic sets' role in modeling the intricate relationship between AI embracement and student engagement.

Research Questions

This research paper aims to answer the subsequent research questions.

1. What is the student engagement level in classrooms?
2. What is the student's perception of the patterns of the use of AI applications in learning?
3. What is the learning outcome of students?
4. What is the interrelationship between students' engagement, patterns of using AI, and student learning outcomes?

3.2 Study Instruments

The study was structured on embracing two measurement scales: (1) ***the Technology Acceptance Model*** (TAM) [8] to investigate how participants perceive AI technologies in classrooms/learning environments and (2) ***The Online Student Engagement Scale*** (OSE) [9], which was adapted to explore students' engagement levels in traditional classrooms. In addition to students' GPA and the demographic questions. [8] developed the Technology Acceptance Model (TAM) measurement to assess users' acceptance and integration of a technology approach, which is the AI application in this study. The model was created to rely on how individuals perceive two variables: perceived ease of use (PEOU) and perceived usefulness (PU) of new technology. The two factors PEOU and PU are used to predict behavioral intentions (BI) toward a technology tool, which is not included here in the study because of its irrelevance to the study objectives. According to [8] theory, the higher the perception of technology to be useful and easy to implement, the more likely students are to anticipate using it, which keeps them more engaged. Additionally, since the mid-1980s, the TAM has been extensively employed in research studies related to the acceptance of technology [28]. For the current study, the TAM was adjusted to quantify students' acceptance of AI applications among college students. The TAM questionnaire contains 3 main subscales, a total of 17 items distributed as follows: six questions in the first subscale to assess the perceived ease of use of AI (PEOU). The second subscale also contains six questions to assess the perceived usefulness of AI (PU). The last five questions are included in the last subscale, which is excluded here. The psychometric characteristics of TAM present a five-point Likert scale, which varies from 1 designating strongly disagree, to 5 indicating strongly agree. The OSE was developed by [9] to determine student engagement while attending online classes. The OSE was aligned to measure students' engagement in traditional classrooms. The questions of OSE were reworded to describe the traditional classrooms integrated with AI. The OSE was developed to contain positively worded 19 questions. The OSE is a 5-point Likert Scale that starts with 1 which presents *not at all characteristics and ends with 5 means very characteristic of me.* All questions assess student behaviors that indicate engagement in learning situations. All statements describe learners' thoughts/emotions like "Staying up on the readings", and "really desiring to learn the material"; skills such as "Posting in the discussion forum regularly" and participation like "helping fellow students" and "posting in the discussion forum regularly"; and performance items like "doing well on the tests/quizzes."

3.3 Scales Validity and Reliability

The two questionnaires that are used here have demonstrated high reliability and validity. For the adapted OSE, the face and concurrent validity were verified in addition to the consensus of a panel of experts. The reliability of the adapted OSE was assessed by calculating the internal consistency of the OSE items [9]. Cronbach's alpha (α) was computed to reveal a high internal consistency with α equal to .86, which suggests a high internal reliability of the scale. Because TAM was tested frequently in the early 1990s, the TAM questionnaire's reliability and validity demonstrated strong consistency [8]. Internal consistency was calculated for both scales TAM and OSE in this study to assess the measurement scales' reliability. Cronbach's alpha indicates internal consistency, which supports the scale's reliability (See Table 1).

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Table 1: The Internal consistency of TAM and OSE Items

Scale	Cronbach's Alpha (α)	*N* of Items
PEOU	.892	6
PU	.892	6
OSE	.905	19

3.4 Study Sample

More than 500 students enrolled in higher education institutions in which AI applications are used in the classroom in the UAE. A total of 367 learners took part in this research inquiry and provided valid responses to the questionnaires. The sample is distributed as (n = 153 (41.7%) males and females (n = 214 (58.3%). Table 2 shows how the participants' ages are classified. As shown in Table 3, the sample is diverse, consisting of people of various nationalities.

Table 2: Sample Categorization by Age

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	18-25	246	67.0	67.0	67.0
	26-33	96	26.2	26.2	93.2
	34-41	25	6.8	6.8	100.0
	Total	367	100.0	100.0	

Table 3: Sample Description by Nationality

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Palestine	51	13.9	13.9	13.9
	Syria	87	23.7	23.7	37.6
	Jordan	65	17.7	17.7	55.3
	India	17	4.6	4.6	59.9
	Pakistan	54	14.7	14.7	74.7
	Egypt/North Africa	32	8.7	8.7	83.4
	UK	18	4.9	4.9	88.3
	Canada	43	11.7	11.7	100.0
	Total	367	100.0	100.0	

3.5 Data Collection

The data collection process began with e-mails and phone calls to a large number of faculty members: professors and instructors, asking them whether they embrace AI in their classes, and if so, their help in data collection is needed. Google Forms was used to create the TAM survey, the adapted OSE questionnaire, and the demographic questions. The IRB was issued, and the consent form was attached to the study link, along with a description of the study and a short video about using AI technologies in education. Participants were sent the link via their university portal, and those who chose to participate provided valid answers. The data was collected over 8 weeks beginning early in March 2023 and continuing until the end of April 2023. To participate in this study, participants must be at least 18 years old and enrolled in higher institutions. All data were anonymized before being transferred to SPSS 24.0 for analysis and reporting.

4. Data Analysis and Results

Before beginning the analysis, the researchers addressed all issues related to missing values, independence, outliers, normality, and variance homogeneity. To answer the first three RQs and find students' engagement levels, the patterns of using AI, and their learning outcomes. The descriptive analysis demonstrated that students showed a remarkable engagement level and a high level of patterns of using AI tools including perceived AI as easy to use and useful in addition to showing positive learning outcomes as explained in Table 4.

Table 4: Outline of the Descriptive Data of TAM measurements

Variable	*M*	*SD*

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Online Student Engagement (OSE)	3.97	.539
Perceived Ease of Use (PEOU)	4.11	.632
Perceived Usefulness (PU)	4.08	.591
Learning Outcome (GPA)	3.64	.396

N=367

Answering RQ 4 mandates computing the Pearson Correlation Coefficient r to find the interrelations between all variables. The results of the Pearson Correlation Coefficient among the adapted OSE, the two subscales of TAM, and learning outcome as measured by students' GPA. Results revealed a moderate to strong positive correlation as shown in Table 5 and Figures 2, 3, and 4.

Table 5: The Correlation between the OSE, the Subscales of TAM, and the GPA

		OSE_Adapted	PU_Total	PEOU_Total	GPA_Total
OSE_Adapted	Pearson Correlation	1	.555**	.644**	.289**
	Sig. (2-tailed)		.000	.000	.000
PU_Total			1	.689**	.349**
PEOU_Total				1	.299**
GPA_Total					1
	N	367			

**. Correlation is significant at the 0.01 level (2-tailed).

As per Table 5, a powerful positive relationship between students' perception of AI as easy to use and useful and their engagement level exists. It was discovered that the more students find AI easy, simple, and useful, the more engaged they will be. So, these three variables share something. Regarding the students' GPA and engagement, it was uncovered that there is a weak positive association between engagement level and the GPA and so for both perception of AI as an easy and useful tool and learning outcome as measured by GPA.

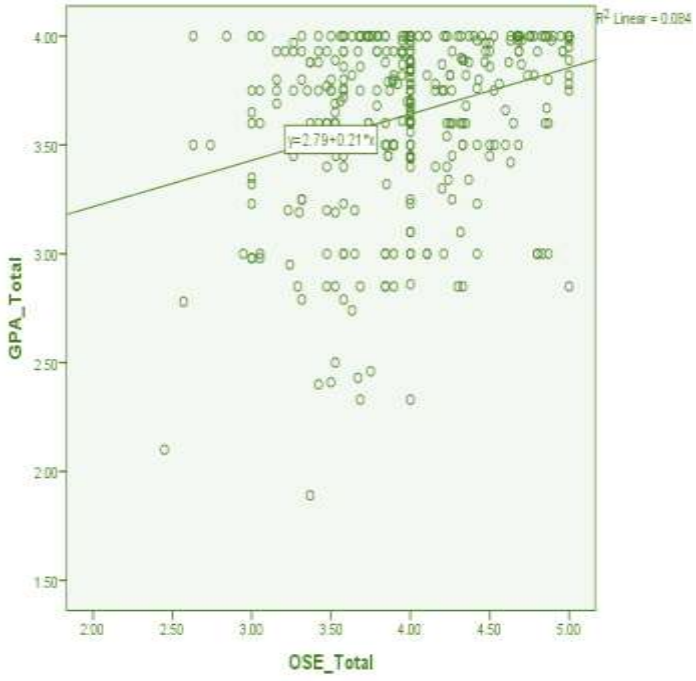

Figure 2: The Relationship Between Student Engagement and GPA

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Received: June 04, 2023 Revised: August 21, 2023 Accepted: November 28, 2023

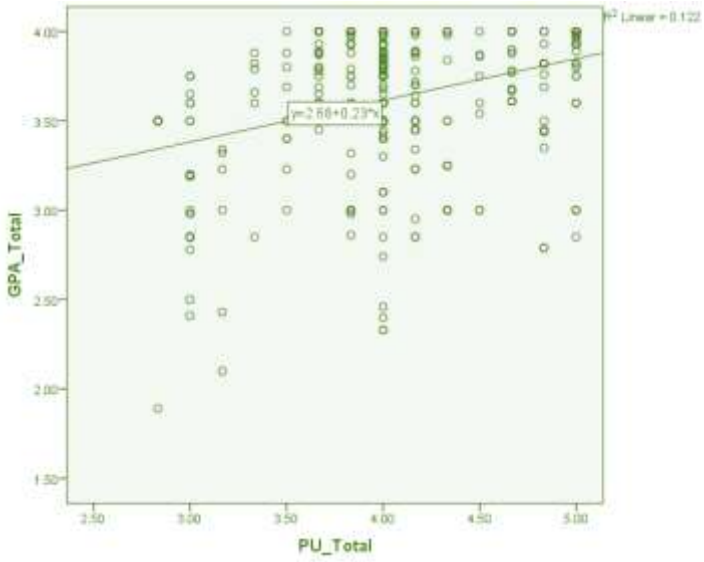

Figure 3: The Relationship Between Perceived Usefulness of AI and Student GPA

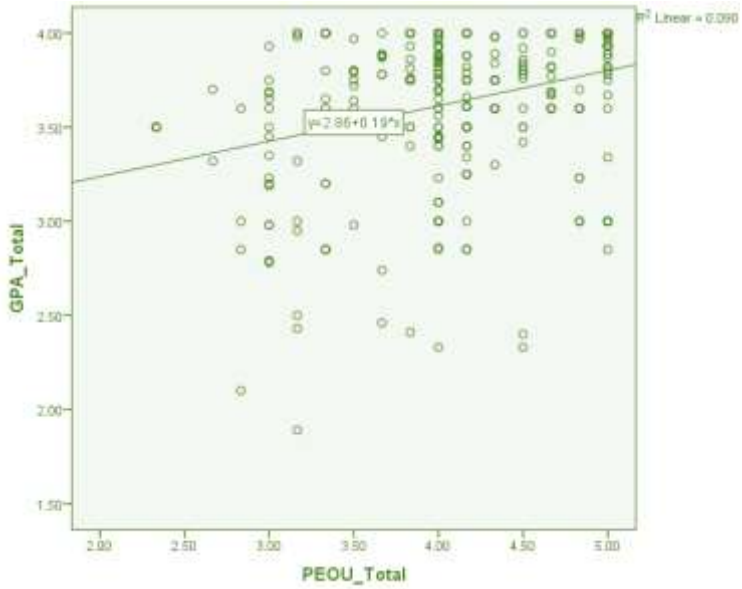

Figure 4: The Relationship Between Perceived Ease of Use of AI and Student GPA

5. Discussions

The current study looks at a critical issue concerning student engagement and the use of AI technologies in classrooms in university settings in the UAE. The quantitative design was used because it was relevant to the study objectives. The findings informed us that students demonstrated a high level of engagement during the sessions in which AI applications were used. Furthermore, students have a positive perception of AI applications as useful and simple to use, which influences their engagement and attention in their classes. Thus, these discoveries can be understood considering the pervasive adoption of modern technology in many educational settings, including higher education; the pervasive adoption of AI makes it simple for people to use it in a variety of fields and daily life activities. Furthermore, the perception of AI applications as simple and beneficial tools promotes student engagement, emphasizing the significance of AI in educational environments. The conclusions are consistent with the findings of [2, 27], who discovered several innovations in AI technologies that encourage professionals and professors to incorporate them into their work duties. The findings revealed that student engagement in classrooms

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is related to two variables: perceived ease of use and perceived usefulness of AI technologies, both of which contribute to student attention and involvement in learning activities. These are expected outcomes; as new technologies become more user-friendly, people will reap the benefits and plan to use what keeps them engaged in the learning environment. These findings are consistent with [22], who discovered that incorporating technology promotes teaching practices and improves students' learning and engagement. The finding of the weak correlation between student engagement and learning outcomes as denoted by student overall GPA, can be explained in the context of measuring learning outcomes, which is not related to engagement only, there should be more variables that contribute to student learning outcomes. Thus, engagement in the classroom is a beneficial tool to attract students' attention and make them use class time wisely but having better achievement needs further effort and endeavors to promote students' learning output. Based on that finding, student engagement has a limited role in student focus in the class but is not a contributor to students' success and academic achievement.

6. Conclusion and Limitations

This research paper describes a non-experimental research study that was conducted to analyze students' engagement and perceptions of embracing AI technologies in classrooms, as well as how this relates to students' learning outcomes in UAE higher education institutions. The findings revealed a high level of student engagement in learning settings where AI applications are used, as well as a positive insight into the patterns of embracing AI applications in the university setting. It was discovered that higher education students regard AI applications as simple tools to use and as supportive of their participation in classrooms. Despite embracing AI in teaching and practice within classrooms, students' learning outcomes are only weakly related to the level of engagement in AI-based learning environments at the college level. The study's limitations include the existence of the correlation, which does not produce cause and effect and thus limits the inferences, as well as the possibility of a confounding factor.

7. Recommendations for Practice

The paper outcomes suggest the succeeding implications for practical application in teaching and learning. Encourage students to use smart AI applications to facilitate student learning to activate the integration of AI in classrooms. One of the recommendations is to allow students to use AI tools as the primary tool for learning and ask them to compare their work (writing or solved problem) to the one produced by the smart applications, which will support student learning and enhance their thinking abilities, as well as be a successful classroom management strategy and keep students connected to the learning environment. Thus, higher education institutions can provide students with an orientation to help them use smart AI applications effectively and avoid misusing these applications, which may limit students' creativity, thinking, and problem-solving skills.

8. Forthcoming Research

The upcoming research study may intend to research the role of AI tools in students' academic achievement by directly tracing their achievement. Furthermore, investigating the use of AI tools while maintaining students' academic integrity.

9. Availability of Data and Materials

The datasets used to achieve this research study are kept anonymous and are available upon request to the corresponding author.

- ***Funding***

The authors declare that there is no funding for the current research study.

- ***Conflicts of Interest Statement***

The authors certify that they have NO affiliations with or involvement in any organization or entity with any financial interest (such as honoraria; educational grants; participation in speakers' bureaus; membership, employment, consultancies, stock ownership, or other equity interest; and expert testimony or patent-licensing arrangements), or non-financial interest (such as personal or professional relationships, affiliations, knowledge or beliefs) in the subject matter or materials discussed in this manuscript.

- ***Acknowledgment:***

The authors verify that this research project was conducted following the research ethics and has been approved by the IRB of the institution with which the authors are affiliated.

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Received: June 04, 2023 Revised: August 21, 2023 Accepted: November 28, 2023

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Doi: https://doi.org/10.54216/IJNS.230121
Received: June 04, 2023 Revised: August 21, 2023 Accepted: November 28, 2023