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Research Article

Exploring the Impact of Artificial Intelligence on Students' Engagement and Motivation in Online Learning Environments

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ABSTRACT

Artificial intelligence-based education provides a new foundation for current educational institutions worldwide, generating improvements in teaching and learning methodologies. The study's primary purpose was to investigate the influence of artificial intelligence, namely ChatGPT, on student engagement and provocation in online learning settings. The study employed a quantitative research methodology. The survey included all undergraduate students from Karachi's public and private sector universities. The researcher used a purposive and snowball sampling technique to select a sample of undergraduate students. A questionnaire was created to collect data. The data were analysed and the major findings demonstrated that ChatGPT had a substantial and favourable influence on students' academic engagement, motivation, and online learning settings. The study emphasized students' increasing involvement with AI in their online learning process, providing useful information for policymakers, educators, and practitioners, allowing them to develop more successful plans for educational institutions.

INTRODUCTION

Before the advent of computers, people made full use of their intelligence. The engagement of educators and students in mechanical educational learning is fully dependent on human efforts. Later, the rapid development of advanced current AI technologies radically altered how humans and machines interacted. As a result of the technological breakthroughs that surround us daily, our intellectual talents and efficiency are continuously increasing. As a result, we must adapt ourselves and our educational system according to the developing new information technology

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(Zohuri & Rehman, 2020). Following the development and use of powerful current AI technologies, the entire globe has become a technology-driven global village. As a result, artificial intelligence, the most sophisticated modern technology, is no longer an assumption for the future but rather a reality of today. The growing need in many aspects of life has raised the appeal of AI. The bulk of students, particularly those in the field of education, use AI technology to quickly access a vast amount of specialized online learning information. As a result, today's students are more interested in using AI for individualized and adapted learning, which makes their education more flexible and accessible (Bagunaid et al., 2022).

According to Shah et al., (2024), AI-powered online learning enables professors and students to collaborate more effectively and successfully via synchronous, asynchronous, or hybrid interactions. According to Saqlain (2023), Pakistan has welcomed AI-based technology in education despite a budgetary disadvantage. As a result, it can help increase the efficacy, inclusivity, and long-term viability of Pakistan's AI-based education system. It will assist students in better preparing to manage the complexity of today's environment and contribute significantly to society. Similarly, Ahmad et al., (2023) highlighted the advancement of AI technology over the last several decades, which has transformed the higher education system in Karachi, Sindh, Pakistan. AI technologies therefore serve both the government and private sectors of education in Karachi by increasing efficiency and providing digital electronic amenities.

Objectives of the Study

The objectives of the study were:

- To examine the effect of AI particularly ChatGPT on students' engagement and motivation in online learning environments.
- To assess the influence of Chat GPT on students' engagement.
- To evaluate the influence of Chat GPT on students' motivation.
- To measure the effect of ChatGPT on students' online learning habits.
- To quantify the role of online learning as a mediator between ChatGPT and students' engagement.
- To evaluate the role of online learning as a mediator between ChatGPT and students' motivation.
- To examine the correlation between students' academic engagement and motivation due to ChatGPT during online learning environments.

Hypotheses

- There is no significant influence of ChatGPT on students' engagement.
- There is no significant effect of ChatGPT on students' motivation.
- There is no significant impact of ChatGPT on students' online learning conduct.
- There is no significant impression of students' online learning ways on their academic engagement.
- There is no substantial impact of students' online learning habits on their motivation.
- There is no noteworthy correlation between students' academic engagement and motivation due to ChatGPT during online learning environments.

LITERATURE REVIEW

The intelligence of machines is referred to as artificial intelligence. John McCarthy coined the phrase "artificial intelligence." He described it as a machine that does work in a manner like that of people. Artificial intelligence, unlike human intelligence, does not have emotions or awareness. Furthermore, artificial intelligence is described as the capacity of programmed machines to do educational tasks in such a quick and easy manner that humans would be unable to do so (Ahmad et al., 2022). AI also provides instructors with the tools they need to access personalized instructional approaches based on individual learners' preferences and needs, hence enhancing motivation and educational engagement (Chen et al., 2020). To equip the educational system with AI, AI-powered technologies must be available. The incredible growth of information and communication technologies has resulted in the creation of AI tools. AI tools are software programs that help solve complex issues or accomplish a variety of academic tasks (Venkatesh, 2022). ChatGPT, the most popular and well-known AI-powered application, has already revolutionized workflows and educational standards (Owan et al., 2023). ChatGPT, an artificial

intelligence technology, therefore plays a key role in elevating traditional education to a higher level of thinking (Leiter et al., 2024).

The ChatGPT's quick generation of more queries and ideas depending on course content may help students enhance their problem-solving and critical-thinking skills. According to Baidoo-Anu and Ansah (2023), these two factors have a crucial role in students' learning engagement. AI-powered learning, particularly ChatGPT, is a potential tool for increasing students' behavioural, emotional, and cognitive engagement in online learning settings. It may encourage students' critical thinking to examine their comprehensive understanding of their learning activities, leading to self-regulated behaviour (Kuraku et al., 2023). Motivation, combined with educational engagement, is essential for students to advance and excel academically to attain excellent educational outcomes in their careers. Student motivation is an important issue in education because it serves as a driving factor that enables students to complete goal-oriented educational tasks (Lo et al., 2023).

Online learning, often known as remote learning, is the transfer of educational information and instructions via the Internet, including web-based courses, video and audio conferencing, and individualized education programs (Martin & Borup, 2022). Digital development enables educational institutions to build a workforce of empowered instructors capable of efficiently navigating the digital world and educating pupils for the challenges of the twenty-first century (Saeed & Kang, 2024). Online learning environments can be synchronous (formal), asynchronous (informal), or a combination of both (blended or hybrid) online learning and teaching experiences, as well as interactions between students and facilitators (Fitria, 2023). Informal and formal online learning using artificial intelligence technology enables the gathering and application of vast amounts of information within student groups (Du et al., 2023). The ChatGPT with hybrid online learning techniques demonstrated a variety of educational welfare benefits, including improved learning outcomes, increased student engagement and happiness, improved self-regulated learning and time management, expanded access and adaptation, and cost-effectiveness.

Previous studies have shown that many students are disinterested in and have low academic engagement in online learning owing to feelings of isolation, a lack of educational motivation, a lack of dynamic and spontaneous connection, and so on. The introduction of AI-powered technologies, including ChatGPT, improved students' online learning settings. It has the potential to enhance learners' individualized learning by encouraging academic engagement and motivation within the context of self-directed distant teaching-learning progression (Ahmad et al., 2023). Therefore, the objective of the research is to give exact and detailed statistical data on the encouragement and incentive of students in Karachi's public and private higher education institutions to participate in AI to make their online learning environments more thought-provoking.

METHODOLOGY

The quantitative study approach was used to explore learners' educational engagement and motivation to utilize Chat GPT in their individualized online learning environments. The study's accessible population included undergraduate students from Karachi's public and private universities. The study utilized a purposive and snowball sampling approach to choose 400 undergraduate students. The research instrument consisted of three components. Section A addressed the respondents' demographic information, including name, age, gender, university name, university type, department name, degree programs, and semesters. Section B included observational questions. Section C included research attitude measures utilizing a five-point Likert scale. There were seven elements for online learning (OL), eight for using ChatGPT (CGPT), seven for student engagement (SE), and seven for student motivation (SM).

Data Collection

The descriptive survey method was used to gather primary data from a sample for the research project. To collect data, the researcher personally visited the selected universities in Karachi. The pilot testing findings on ChatGPT (CGPT) indicate Cronbach's alpha value (α = 0.851), indicating a strong index of reliability. Cronbach's alpha (0.705), another dependability metric, was noted in the Online Learning (OL) findings. Cronbach's alpha (0.832) indicated a good level of consistency in the results for student engagement (SE). Finally, the results for student motivation (SM) showed a Cronbach's alpha value of

0.861, indicating a satisfactory reliability index. The data was cleaned to ensure that there were no missing values, miscoding, unengaged responses, or outliers. The Shapiro-Wilk test was used to determine that the study data was normally distributed with p >.05. The gathered data was examined through IBM SPSS (v. 22) and IBM Smart PLS (v. 24) software.

Confirmatory Factor Analysis

Confirmatory Factor Analysis (CFA) is a statistical procedure that evaluates the factor structure of a set of observed data. CFA enables researchers to test the notion of a relationship between observable variables and their underpinning latent components. For covariance-based structural modelling (CB-SEM), the researchers employed the CFA approach. The CFA was used to assess the validity and reliability of each component using the average variance extracted (AVE). As a result, it was important to evaluate the model's anticipated fitness in the end. The model augmentation method involved bootstrapping the model to ensure it met the necessary levels. The researcher removed the items with low factor loading. Furthermore, further trials were conducted to get the necessary level. The reliability values exceed 0.7; hence, each factor was computed using these parameters. Table 1 shows that Cronbach's alpha values are larger than 0.7.

Table 1

CFA Model of Measurement

Reflective Scale	Factor Loadings	Cronbach's Alpha	CR	AVE
ChatGPT				
CGPT1	0.645	0.814	0.826	0.547
CGPT2	0.805			
CGPT3	0.759			
CGPT4	0.740			
Online Learning				
OL 4	0.586	0.713	0.719	0.579
OL 5	0.788			
OL 6	0.724			
OL7	0.902			
Academic Engagement of Student				
SM1	0.805	0.825	0.825	0.539
SM2	0.798			
SM3	0.728			
SM4	0.824			
SM5	0.837			
SM6	0.853			
Motivation of Students				
SE1	0.745	0.870	0.872	0.530
SE5	o.764			
SE6	0.806			
SE7	0.747			

CR = Composite Reliability
AVE = Average Variance Extraction

The CFA model of measurement was evaluated by deleting eleven (11) statements. Statements that were excluded included CGPT 5, CGPT 6, CGPT 7, CGPT 8, OL1, OL2, OL3, SE2, SE3, SE4, and SM7. They were removed from the study due to their low factor loading of less than 0.600 (Geffen & Straub, 2005). The study assessed the construct's reliability using Cronbach's alpha (α) and composite reliability (CR). Table 1 shows that all the composite reliability (CR) values were above the suggested limit of 0.700. Convergent validity was detected since Table 1 showed that the average variance extracted (AVE) for reliability and validity of factor loadings was more than 0.500.

Table 2

Inter-Construct Correlations and Square Root of AVE (Fornell–Larcker Criterion)

Constructs	ChatGPT	Online Learning	Students' Engagement	Students' Motivation
ChatGPT	(0.749)			
Online Learning	0.478**	(0.772)		
Students' Engagement	0.768**	0.194**	(0.786)	
Students' Motivation	0.759**	0.186**	0.648**	(0.856)

$^{**}p < 0.01$, $^{***}p < 0.001$

The discriminant validity was examined using the Forwell-Larcker criterion, which revealed that the square root of the average variance extracted (AVE) for the construct was greater than the inter-construct correlation, indicating discriminant validity. As a result, the study's conception demonstrated discriminant validity.

Table 3

Heterotrait-Monotrait Ratio

	ChatGPT	Online Learning	Students' Engagement
ChatGPT			
Online Learning	0.472		
Students' Engagement	0.784	0.367	
Students' Motivation	0.764	0.349	0.851

The Heterotrait-Monotrait ratio (HTMT) of correlation is another measure of discriminant validity. The HTMT approach is effective for calculating the real correlation between two latent variables. The HTMT threshold should be smaller than 0.90. An HTMT test score of 0.90 or above indicates a lack of discriminant validity. However, this study stated that the HTMT values were less than the threshold figure of 0.90, indicating that the scale was genuine. As a result, the discriminant validity of the concept used in this investigation was demonstrated.

Table 4

Collinearity Analysis and Model Fit Indices

Dimensions	Variance Inflation Factor (VIF)	Model Fit Indicators
ChatGPT→OL	1.003	SRMR = 0.08 d_ULS = 0.07 d_G = 0.06 NFI = 1.00
ChatGPT→SE	1.175	
ChatGPT→SM	1.175	
OL→ SE	1.175	
OL→ SM	1.175	

Abbreviations: VIP (Variance Inflation Factor), SRMR (Standard Root Mean Square Residual), NFI (Normal Fit Index), d_ULS (root Mean Square Error of approximation), d_G (Goodness of Fit). The collinearity error (VIF) was reduced during the structural equation modelling evaluation. The variance inflation factor has a threshold value of less than 5, otherwise, the problem of collinearity emerges if the VIF exceeds five (Huang, 2021). According to the research investigation, the VIF value was between 1.003 and 1.175. Consequently, table 4 showed that there was no collinearity between constructs. Furthermore, Hu and Bentler (1998) discussed the four key indicators used to assess model fitness: SRMR, d_ULS, d_G, and NFI. The values of SRMR vary from 0 to 1. Table 2 shows that the study's estimated value model had an SRMR value of 0.08. As a result, it was approved, demonstrating that the study's model was fit. Furthermore, the NFI value ranges from 0 to 1. Table 4 shows the NFI value of 1.00. As a result, it was approved, and the study's model was appropriate.

Ethical Considerations

Ethical consideration is a critical component in conducting research studies to protect respondents from any ethical disturbance. Consequently, the researcher took the following steps:

- The HODs of all departments signed a permission letter outlining the research study's goal and the role of respondents.
- Participants' identities and addresses were kept unidentified.
- The data from this research study were confidential. Only the researcher could have access to the research data.
- The researcher adhered to university laws and regulations, avoiding any activities that may humiliate students.

Descriptive Statistics

Descriptive statistics for the research data set included 400 undergraduate students to emphasize their demographic information. The respondents' ages ranged from 17 to 46 years. The variation between students' minimum and maximum ages is 29 years. The mean age was 23 years old. The standard deviation (SD) value of 4.11 demonstrated the dispersion of age-related data points around the mean location. The pupil's age range was 16.9 years. As a result, the age distribution of the pupils was right-skewed and leptokurtic, with flatter peaks. There were 400 undergraduates, with 212 men and 188 females, representing 53% male and 47% female undergraduate students. As a result, men were assigned a minimum value of 1 and females were given a maximum value of 2 to create a range of 1. The gender distribution was favourably skewed, scattered, and followed a platykurtic with high peaks.

The 400 undergraduate students were chosen from a sample of four general universities: 118 undergraduate students from Iqra University, 98 undergraduate students from Karachi University, 70 undergraduate students from Hamdard University, and 114 undergraduate students from Sindh Madrassah Tul Islam, representing 29.5%, 17.5%, 24.5%, and 28.5%, respectively. The distribution of university numbers had a negative slope and was leptokurtic, with flat peaks. The research study divided four general universities in Karachi into two different groups: two private universities (Iqra University and Hamdard University) and two government universities (Karachi University and Sindh Madrassah Tul Islam University). In addition, 188 undergraduate students from two private institutions and 212 from two public universities scored 47% and 53%, respectively. Furthermore, the distribution of these four universities was negatively skewed and leptokurtic.

The researcher gathered data from respondents studying in ten different departments at the universities, including 37 students from Media Studies, 118 from Social Sciences, 68 from Business Administration 38 from Computer Science, 35 from English, 24 from Chemistry, 27 from Mathematics, 27 from Physics, 09 from Fashion Designing, and 22 from Psychology, accounting for 29.5%, 17%, 9.3%, 8.3%, 8.8%, 6.8%, 6.0%, 6.8%, 2.3%, and 5.5%, respectively. As a result, the number of departments ranged from 1 to 10, with a mean of 3.92. The departments' distribution was positively skewed, consistent with the leptokurtic pattern. The respondents were enrolled in five distinct degree programs, including B.Ed., 168 from BS, 52 from M.Sc., 27 from B.Sc., and 35 from B.C., accounting for 44%, 29.5%, 6.8%, 13%, and 8.8%, respectively. Furthermore, the distribution of degree program data was positively skewed and leptokurtic. The undergraduate students in the research study studied in various semesters, including 52 from the 1st, 38 from the 2nd, 95 from the 3rd, 96 from the 4th, 62 from the 5th, 37 from the 6th, and 37 from the 7th semesters, with 13%, 9.5%, 23.8%, 24.0%, 15.5%, 9.3%, and 5%, respectively. The semester data distribution had a variance of 2.662, passive skewness, and was leptokurtic with flat peaks.

Conceptual Framework

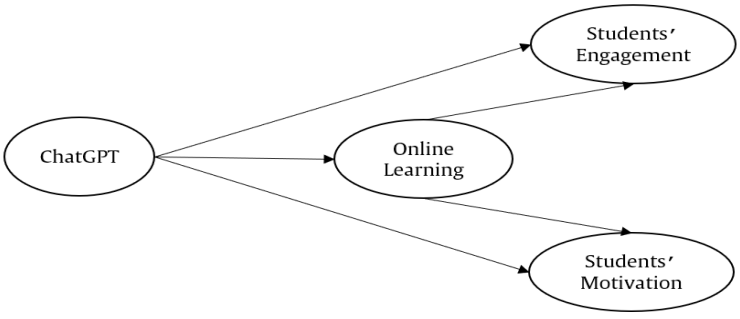

Fig. 1. Conceptual Framework

Figure 1 depicts the conceptual framework using ChatGPT as the exogenous variable. The researchers purposely modify exogenous variables to see how they affect endogenous variables like student academic engagement and motivation. Online learning serves as the intermediary variable between them. Mediation of online learning demonstrates how the ChatGPT improves online learning, and hence student motivation and engagement. ChatGPT boosts university students' motivation, academic engagement, and online learning in either a direct or indirect manner. Mediation may be partial, complete, or insignificant.

Inferential Statistics

PLS-SEM

Partial least squares structural equation modelling (PLS-SEM), often known as PLS route modelling, is a popular multidimensional data analysis tool among social sciences and humanities researchers (Memon et al., 2021).

Estimation of Partial Least Square Structural Equation Modelling

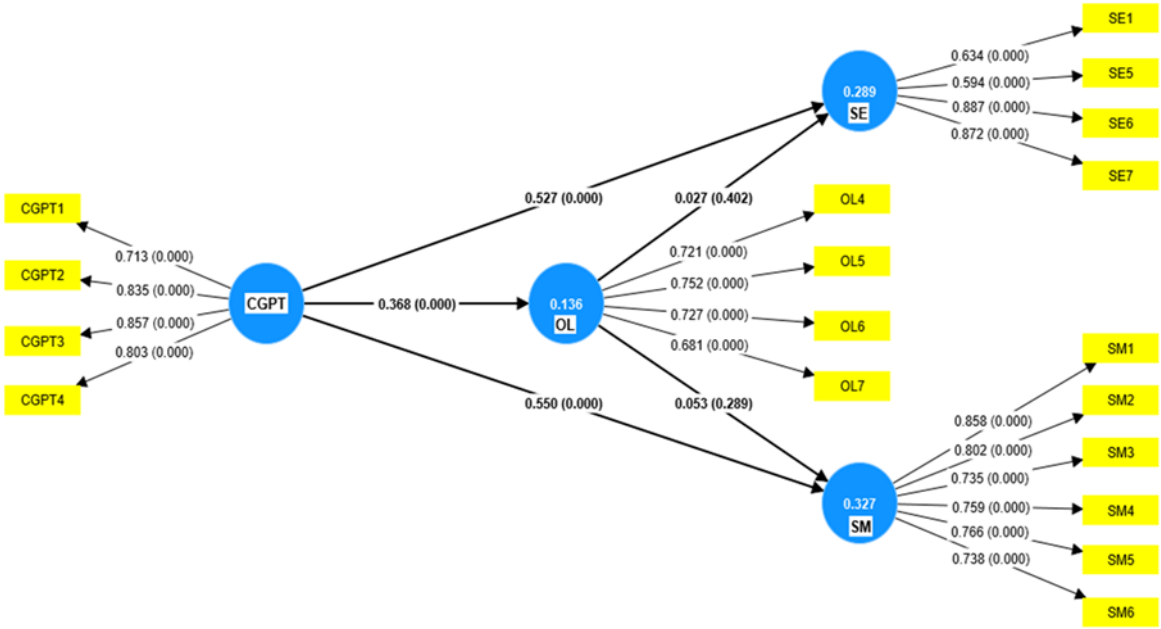

Fig. 2. Measurement Model

Figure 2 depicts the measurement model, in which the outer model links latent factors (ChatGPT, online learning, student engagement, and motivation) to tangible variables (Likert scale statements). Furthermore, causal linkages between latent variables can define the inner model. Huang (2021). This PLS structural model revealed a significant portion of the variation in the dependent variables (student involvement and motivation) using R square values. Memon et al., (2021) discovered that bootstrapping confidence intervals and p-values supported the statistical importance of research hypotheses while also sustaining the research theoretical framework.

Path Analysis

The coefficient of determination (R2) measures the model's explanatory ability. The exogenous variable (ChatGPT) was shown to explain a fraction of the variance in the endogenous latent variables (online learning, student involvement, and student motivation). As a result, online learning is considered to have modest explanatory power (R2 = 0.136). Whereas student involvement (R2 = 0.289) and motivation (R2 = 0.327) are thought to have significant explanatory power.

Table 5
Structural Model (Path Analysis)

Hypothesized Relationships	Standardized Estimates	T value	Null Hypotheses	P value	Decisions Taken
ChatGPT→OL	0.086	4.411	H0 1	0.000	Upheld
ChatGPT→SE	0.107	4.918	H0 2	0.000	Upheld
ChatGPT→SM	0.077	7.142	H0 3	0.000	Upheld
OL→SE	0.107	0.249	H0 4	0.402	Unsupported
OL→SM	0.095	0.557	H0 5	0.289	Unsupported

The path analysis in Table 5 demonstrated that ChatGPT, an independent variable, had a direct influence on online learning, educational engagement, and motivation of undergraduate students, all of which were dependent factors. Furthermore, it revealed ChatGPT's indirect influence on students' academic engagement and motivation through online learning as a mediator variable. The study's null hypotheses were supported or rejected at $p > 0.01$ and $p < 0.01$, respectively.

Direct Effect Analysis

The Impact of ChatGPT on Students' Engagement

Table 5 demonstrates that ChatGPT has a favourable and very significant direct influence on students' academic engagement. The standardized estimate revealed a significant path coefficient ($\beta = 0527$, $p = 0.000$) between ChatGPT and student academic involvement. It demonstrated the promising and very significant relationship between ChatGPT and student involvement by rejecting the 1st null hypothesis. Thus, ChatGPT has a foremost impact on student engagement.

The Impact of ChatGPT on Students' Motivation

Table 5 assessed ChatGPT's significant beneficial influence on university students' motivation. ChatGPT has a favourable and substantial direct influence on students' motivation, as indicated by the path coefficient ($\beta = 0.550$, $p = 0.000$). As a result, the 2nd null hypothesis was not supported. Hence the alternative hypothesis was validated, indicating that ChatGPT has a considerable influence on student motivation.

The Impact of ChatGPT on Online Learning

Table 5 showed a high positive connection ($\beta = .357$, $p < 0.01$) between ChatGPT and online learning. Accepting the alternative hypothesis did not provide evidence for the 3rd null hypothesis. Therefore, ChatGPT has a substantial influence on online learning.

Indirect Effect Analysis

Table 6
Results of Mediation Analysis for Indirect Effects

Types of Effect	Effects	Path Coefficient	P-value	Remarks
Direct Effect	ChatGPT→SE	.613	.001	Substantial Direct Effect
	ChatGPT→SM	.591	.001	
Indirect Effect	ChatGPT→OL→SE	-.201	.354	Insignificant Indirect Effect
	ChatGPT→OL→SM	-.136	.759	
Total Effect	ChatGPT→SE	.597	.001	Significant Total Effect
	ChatGPT→SM	.583	.001	

The Impact of Students' Online Learning on their Academic Engagement

Table 6 showed that the path coefficient ($\beta = 0.027$, $p = 0.402$) between students' online learning practices and academic involvement did not reach statistical significance. As the $p > 0.01$, the 4th null hypothesis was maintained, indicating that students' online learning did not have a significant effect as a mediator between ChatGPT and undergraduate academic engagement.

The Impact of Students' Online Learning on Their Motivation

Table 6 indicated that the path coefficient (β = 0.053, p = 0.289) did not reach statistically significant levels for the influence of online learning on learner motivation. Because p > 0.01, the study accepted the 5th null hypothesis, rejecting the function of online learning as a mediator between ChatGPT and student motivation.

No Meditating Effect of Online Learning between ChatGPT and Students' Academic Engagement and Motivation

The outcomes of the mediation path analysis suggested that online learning had no mediating influence on the association between ChatGPT and undergraduates' educational participation and motivation at Karachi's general universities. These findings demonstrated that online learning did not serve as a possible buffer for students' academic engagement and motivation when they supplemented their customized learning with ChatGPT.

Table 7

Correlation between ChatGPT with Academic Engagement, Learners' Motivation, & Online Learning of Undergraduates

Variables	Mean	SD	OL	CGPT	SE
OL	25.80	5.321			
CGPT	27.20	6.997	.363**		
SE	24.51	5.957	.363**	.736**	
SM	24.38	6.097	.353**	.736**	.779**

*Note: N=400, ** p < 0.01 level (2-tailed); *p < 0.05*

Table 7 presented the Pearson correlation coefficient, which was determined to determine the linear relationship between variables. ChatGPT and online learning showed a positive, modest association, r (400) =.363, p =.000. Furthermore, there was a high positive association between ChatGPT and learners' engagement, r (400) =.736, p =.000. It also revealed a high positive relationship between ChatGPT and student motivation, r (400) =.779, p =.000. Accepting the alternative premise that ChatGPT has a major impact on students' engagement and motivation in online learning settings.

RESULTS & FINDINGS

It was possible to conclude by estimating the route analysis of partial least squares structural equation modelling (PLS-SEM). These findings were grouped according to the study's aims as follows:

- ChatGPT (CGPT) significantly improves student academic engagement (SE)
- ChatGPT (CGPT) significantly increases student motivation (SM)
- ChatGPT (CGPT) has a significant impact on online learning (OL) for university students
- Online learning did not significantly affect respondents' academic engagement (SE)
- Online learning does not substantially influence student motivation (SM)
- ChatGPT significantly improves student engagement and motivation in online learning environments

Hence, the indirect impact failed to support the mediation of online learning between ChatGPT and respondents' educational engagement and motivation.

Discussion

ChatGPT had a substantial, positive, and highly significant influence on students' academic engagement, which is comparable with the study Shahzad et al., (2024) which, while done in an industrial setting, focused on the development of professional skills and capacities. This research, however, focuses on the personal development of individual talents through the employment of certain machines and technologies. ChatGPT has a significant advantageous impact on student motivation. ChatGPT had a major impact on university students' online learning situations. As a result, Arshad et al., (2024) underlined the significance of working between artificial and human intelligence to produce more engaging online learning environments using versatile and adaptable instructional resources. However, using online

learning as a mediator has had no major effect on undergraduate students' academic engagement and motivation. Caraig and Fabro (2022) discovered that using online learning as a mediator had no significant effect on students' academic engagement and motivation in online learning contexts.

CONCLUSION

The conclusion of this study is mostly based on the precise findings of the current study, which revealed that ChatGPT had a strong positive and substantial influence on the educational participation, motivation, and online learning mindsets of undergraduate students at Karachi higher education institutions. The study also found that an increased use of ChatGPT among undergraduate students would encourage educators, policymakers, and educational practitioners to consider more broad steps to improve online learning environments through AI-powered tools within educational institutions. It would be beneficial to lessen the digital divide between instructors and students by converting traditional teaching-learning approaches into hybrid learning environments in the education sector. As a result, this study confirmed that technology supplemental products, rather than replace, traditional methods of instruction. However, this study has certain limitations. The small sample size and focus on a specific educational framework may have impacted the data's generalizability. Furthermore, the study relied on self-reported measures of involvement and motivation from university students, which might be skewed. A future study will use a qualitative research methodology to investigate the impact of using ChatGPT in a range of educational contexts and with bigger, more varied populations.

Recommendations

- The study recommends that educators, politicians, and practitioners consider providing technical amenities like equipment, infrastructure, and systems in Karachi's higher education system.
- The AI-based mixed digital teaching and learning environment bridges the digital rift between educators, teachers, and students.
- At the government level, it would be beneficial to ensure fairness in higher education, ensuring that all students, regardless of socioeconomic background, have access to digital literacy. As a result, the government should plan to supply computers to graduate students to help them in completing their educational obligations.
- ChatGPT, an AI technology, is becoming increasingly popular in higher education in Karachi. As a result of this better tendency, curriculum creators should incorporate knowledge about artificial intelligence technologies into the curriculum at the grassroots level to boost learners' intellectual levels.
- While designing ChatGPT, policymakers promised the AI designers that it would be accurate. Providing factual knowledge to enhance undergraduate students' well-being and cognitive abilities
- Policymakers should organize workshops for instructors to learn about AI technology and how they may help university students learn online.
- The study emphasizes the need to use AI-based technology in educational initiatives for improved effectiveness and innovation. It would be beneficial to maintain the interactive level of students in online learning environments.

Competing Interests

The authors declared no competing interests.

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