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Learning Engagement through Generative AI Chatbots: The Mediating Roles of Instructor Support and Learning Motivation in Jiangsu Province, China

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Abstract: *In recent years, the use of AI in educational settings has become a significant avenue for the evolution of the application of new and interactive learning experiences. Among all kinds of AI technologies available nowadays, generative AI chatbots are the most reliable, being the ones, which can support interactive, personalized, and responsive learning environments. This study is primarily centered on the role of generative AI chatbots in promoting student engagement in higher educational institutions of Jiangsu Province, China. The research, to be more specific, observes the effect of five independent; Perceived Usefulness, perceived ease of use, the frequency of chatbot use, digital self-efficacy, and feedback responsiveness; on learning engagement, where instructor support and learning motivation are mediating variables. This study utilized Technology Acceptance Model (TAM) and Self-Determination Theory (SDT). A quantitative methodology approach, a structured questionnaire was utilized where the samples were university learners and educators that used AI chatbots. The SEM (Structural Equation Modeling) was used to analyze the data so as to realize the assessment of the hypothesized relationships and mediation effects. The initial expectation was that, there would be a positive relationship between students' perceptions of chatbots and their usage with learning engagement, especially when the instructor is facilitative and the student is motivated. By that, the study wins the race in AI educational development; it is also a practical example to other educators who want to know what types of chatbot strategies can be effective. Besides this, the findings yield the most practical and actionable insights for those designing policy, teachers, and creators of EdTech who want to build learner-centered AI environments.*

Keywords: Generative AI Chatbots; Learning Engagement; Digital Education; Instructor Support; Student Motivation

1. Introduction

The rise of artificial intelligence (AI) has been a factor of the significant shifts in nearly every industry, and education is no exception. As digitally-based learning becomes more prevalent, the educators and educational institutions often consider incorporating AI technologies to implement great personalization, efficiency, and responsiveness (Wang & Sun, 2025). Among the latest technologies of this type, generative AI chatbots based on natural language processing and machine learning algorithms are most vivid because they simulate real conversations, suggest answers in real-time, and change according to individual students' interests. The

technology not only assists teachers but also has the potential to carry out several functions such as tutoring, feedback provision, content recommendation, and emotional support which in turn, enables a more engaged learning and better academic performance.

The People's Republic of China, which is strong in AI capabilities and offers digital infrastructure, is a place where the educational institutions have been actively testing the embedding of AI-driven solutions. There has been a growing number of generative AI chatbots appearing at universities and schools, especially as part of learning platforms and mobile applications (Akpan et al., 2025). The trend is part of the national schemes to implement the operational modernization of the education sector through the technological innovations. Yet, in spite of the technical drive, some of the persistent challenges facing Chinese educators and researchers are related to student learning engagement. Passive learning, low intrinsic motivation, and inconsistent instructional support are some of the reasons, which often, even the use of advanced digital tools cannot overcome. What's more, the impact of generative AI chatbots on educational outcomes cannot just be referred to the technology itself, but it also relies on the specific pedagogical environment where they are utilized.

One of the regions in China which is a well-known economic and technological development epicenter is Jiangsu Province making this site a good candidate for the study. The province has a variety of higher education institutions which have made significant progress in the digital learning sector; thus, it is a good spot to assess the pedagogical innovation created by generative AI tools. Notwithstanding, the high tech of the educational sector, the discussion about how these tools affect the cognitive, emotional and behavioral engagement the key dimensions of a more holistic education- still exists. Moreover, the contextual factors, such as instructor support and student motivation, which mediate the relationship between chatbot technologies and learning, need to be studied more.

This research targets to investigate the extent generative AI chatbots could help in the improvement of both engagement and learning of the students in Jiangsu Province. The Independent variables for the study are Perceived Usefulness, Perceived Ease of Use, Frequency of Chatbot Usage, Digital Self-Efficacy and Feedback Responsiveness (Mun & Hwang, 2025). Their influence on Learning Engagement directly and via Instructor Support and Learning Motivation as mediating variables will be examined by the researchers. The basis of the exploration is firmly planted in the Technology Acceptance Model (TAM) and Self-Determination Theory (SDT) which offer the theoretical framework on the interaction of technology, pedagogy, and learner psychology.

The outline of this paper runs as follows. The second section is presents a literature review on the generative AI chatbots issues and the related factors that affect learning engagement. This part is followed by the theoretical and conceptual frameworks that guide the research. The methodology section presents the research design, data collection methods, and analysis procedures. Subsequently, the results and findings are presented and interpreted, followed by a discussion on their implications. The paper ends with a summary of contributions, limitations, and recommendations for future research and educational practice. Through this exploration of generative AI chatbots the study, in turn, aims to shed light on the design and execution of AI-augmented learning strategies within China and other settings.

2. Literature Review

The increasing prevalence of AI chatbots in educational institutions--especially in China--has resulted in the desire for empirical research to see the new learning engagement of students due to these tools (Chakravarty, 2022). Technology Acceptance Model (TAM) and Self-Determination Theory (SDT) principles of recent investigations have been about the ways that students' beliefs and digital skills together with instructor mediation and motivational dynamics can have an influence on the effectiveness of chatbots. The variables include-Perceived Usefulness, Ease of Use, Frequency of Use, Digital Self-Efficacy, and Feedback Responsiveness-linked to Instructor Support and Learning Motivation, that brings about the ultimate outcome, in this case, Learning Engagement, which is a multifaceted concept of emotional and cognitive commitment as well as behavioral intention.

Perceived Usefulness and Perceived Ease of Use

The Technology Acceptance Model (TAM), according to Perceived Usefulness (PU) and, on the other hand, Perceived Ease of Use (PEOU) make up the two major pillars of the technology acceptance. A report published by Li and collaborators (2024) in the journal Scientific Reports explores the extension of this model to the participation of students in artificial intelligence (AI) education (Li, 2024). They have shown that PU and PEOU have a dramatic influence on students’ both learning motivation and behavioral intention for using AI platforms, especially when usability fitting with students’ goals and prior experiences (Li et al., 2024).

Besides, in Pakistani research on the linguistics course, the students assumed chatbots to be a valuable tool for not only learning but also performance improvement. Their positive perceptions of chatbots as easy-to-use tools and useful learning resources were directly associated with increased motivation and the persistence of usage patterns (Koka, 2024).

Frequency of Chatbot Use

Chatbots, which are now the most commonly integrated tool in study, have proven beyond any doubt their high frequency of use. Wei et al. (2025) applied the method of log analysis concerning Chinese EFL learners that revealed the fact that students who often made use of chatbots managed to enhance their oral English skills as a result of chatbots' higher exposure and provision of immediate feedback. The practical use of chatbots very often has its first set time by being the most useful and easiest to use for whom (Wei et al., 2025).

Digital Self-Efficacy

The acquiring of communication skills through various methods by people in diverse areas/service sectors is the basis of this research study. Han (2024) observed that the ability of the users of the massive open online course sessions chatbots to perform the functions of informational LOs using the speech act only was the major factor that defined their self-regulated learning, which in turn enhanced their cognitive and behavioral engagement positively (Han, 2024).

Feedback Responsiveness of Chatbots

Feedback responsiveness, viewed as the immediacy and the caliber of the AI feedback, is one motivational machine for learning. The study carried out by Wang and Wu (2025), which incorporated both qualitative and quantitative parts, made it known that the chatbot answers had in certain cases a good influence on the intrinsic motivation of the students whose anxiety in design theory was alleviated by the feeling of autonomy. The observations of comments

being customized and backing students, prior learning through experiences with AI or not, were a function of whether engagement increased or not (Wang & Wu, 2025).

Instructor Support as a Mediating Variable

According to Self-Determination Theory (SDT), the support and guidance sought from teachers are the most significant means for students to get their psychological needs met (Guay, 2022). Hidayat-ur-Rehman (2024) mentioned that student participation was associated with the perception of the teaching staff scaffolding-in which the teachers acted as mediators of AI feedback; and chatbot utilization, respectively. AI-powered tools, which were used with care by teachers, not only provided students with the required facts but also assisted in creating an emotionally balanced environment for learning (Hidayat-ur-Rehman, 2024).

Learning Motivation as a Mediating Variable

The effectiveness of the chatbot is mainly due to the strong motivation, particularly the inner motivation (Yin et al., 2021). According to Sulaiman and the oncologists (2025) personalized chatbots were found to be a great help for students in terms of their autonomy and motivation because students who they were using AI-integrated mobile platforms for English learning gamified and autonomous nature of chatbots. The motivational benefits are necessary for students' participation in the more learning process and for students' role in successfully achieving academic goals (Sulaiman et al., 2025).

Learning Engagement

In fact, the emotional, cognitive, and behavioral aspects are all involved in learning engagement. Chatbots are the program, which the researchers have found that they can be used to foster time-on-task, raise learner curiosity, and build self-discipline, particularly if they are aligned with students' interests and the teaching objectives. The engagement strategies, which were mainly effective, were role-playing, reflective prompts, and self-assessment integrations (Wiboolyasarin et al., 2025).

China-Specific Studies

The understanding of specific phenomena has been demonstrated through the investigation conducted in China (Wang & Xu, 2022). It is a country where the variables of cultural requirements and technical growth differ. Zhou and their fellows (2025) identified that the motive of pre-service teachers for the use of chatbots changes according to the level of institutional trust, previous digital experiences, and teacher-centered norms. In the same way, Hu and his team (2025) stated that learning motivation in Chinese pre-service teachers was to a great extent influenced by perceiving AI benefits and autonomy in teaching (Hu et al., 2025).

Recent studies have confirmed that there is a twofold link technologically perceived (PU, PEOU), practicing habits (frequency), psychological precondition (self-efficacy), and teaching conditions (instructor support, feedback, motivation) in change of learning engagement. The results also demonstrate that not only the technological framework but also the physical and motivational structures based on proper instruction are essential for the proper AI chatbot functioning in education, especially in China (Chiu et al., 2024). Besides, these results exceed the theoretical base used in the research study in Jiangsu Province and propose that other nations undergo and establish different methods for the required comparison and longitudinal studies.

3. Underlying Theories

The research aims to explore the function of the generative AI chatbot in the scenario of technological affordances, learner psychology, and teaching dynamics in promoting learning engagement in Jiangsu Province, China. It is using the Technology Acceptance Model (TAM) and Self-Determination Theory (SDT) as the underlining frameworks.

Technology Acceptance Model (TAM)

The Technology Acceptance Model (TAM) that was first proposed by Davis (1989), is one of the most recognized and respected models when it comes to the understanding of user acceptances of novelties like digital technologies. In the foreground of the current research, one of the cornerstones of TAM is exploring the application of how students perceive generative AI chatbots such as their PU and PEOU, affecting their adoption of such tools for learning (Chiu, 2025).

Perceived utility is how much students feel that AI chatbots have an effect such as improving their class performance. For example, when students consider chatbots to be credible sources for real-time feedback, individualized instruction, or tailored content they are more prone to use them in their learning sessions (Chang et al., 2023). Conversely, PEOU refers to the physical and mental workload that students expect to deal with when using actual technologies. If the interface of a chatbot is user-friendly and its functions are visible and easy to access, then students will be less likely to get problems related to technology and will be able to use it more often and more importantly.

TAM therefore theorizes that high PUs and PEOFs cause increases in actual system usage, which leads to the individual getting involved more deeply in the process of learning (Alyoussef, 2022). The digital education environment of Jiangsu, on the one hand, has a strong technological base with projects around Artificial Intelligence proliferating at a rapid speed thus these beliefs are absolutely fundamental starting points for the use of chatbots in higher education.

Self-Determination Theory (SDT)

This research is based on Self-Determination Theory (SDT) and the motivation and contextual that mediate learning engagement. SDT, which was build out by Deci and Ryan (2000), points out that the primary condition for intrinsic motivation is the satisfying of three basic psychological needs: autonomy, competence, and relatedness.

The support of the instructor, as it is expressed in the context of SDT, is the main key to enclose these needs. Supportive instructors promote autonomy by giving students the right to learning choices they want, competence by directing them to the solutions of academic challenges they face, and relatedness by creating safe and emotionally supportive environments. Apart from the fact that support is added to the AI chatbot, it helps augment the educational value of the chatbot by discussing and critically engaging with the information it provides (Roca et al., 2024). The instructor is the key in the process of scaffolding AI due to the fact that, especially in countries like China where cultural norms continue to favor teacher-centered learning, the instructor has a paramount role.

Another central SDT construct that has to do with this study is learning motivation, both intrinsic and extrinsic (Luo et al., 2021). Students have the intrinsic motivation to learn and they study new topics because they are curious, they like them, or they desire to master those

skills-the inner motives are further heightened when they gain the feeling of competence by using digital tools and getting feedback from both instructors and AI. Extrinsically motivated learners may get started by means of chatbots for grades or other external rewards but they might later become more self-determined as they progress through knowledge and skill.

Integrating TAM and SDT to Explain Learning Engagement

The conciliation of TAM and SDT makes it possible for the present author to explicate the interaction between the technological and psychological variables and the resultant influence on the student engagement in AI-mediated learning environments (Xu et al., 2025). It was TAM that provided a clear-cut explanation of the way perceptions related to chatbots (PU and PEOU) directly influence behavior, whereas SDT laid out the hidden verifiable causes of motivation that were affected by the instructor's provision of support and the learner's freedom of choice.

As for Jiangsu Province, a high-tech yet pedagogically diverse area in China, the inclusion of generative AI chatbots in higher education settings is both an opportunity and a challenge. The utility and ease of use were the main TAM elements that affected the decision of the students regarding the chatbot engagement (Lin, 2024). In contrast, the variables identified by SDT (instructor support and motivation) were responsible for determining the depth and quality of that engagement. Although these are different approaches, they create a unified model that students' participation in learning is not solely dependent on the rate of technology adoption but instead is a dynamic effect of motivation, teaching, and usability.

This two-theory outlook hence stands as the underlying framework for the scrutiny of how digital education tools like generative AI chatbots can bring about meaningful engagement when they are deployed in learner-centered, instructor-supported ecosystems.

4. Conceptual Framework

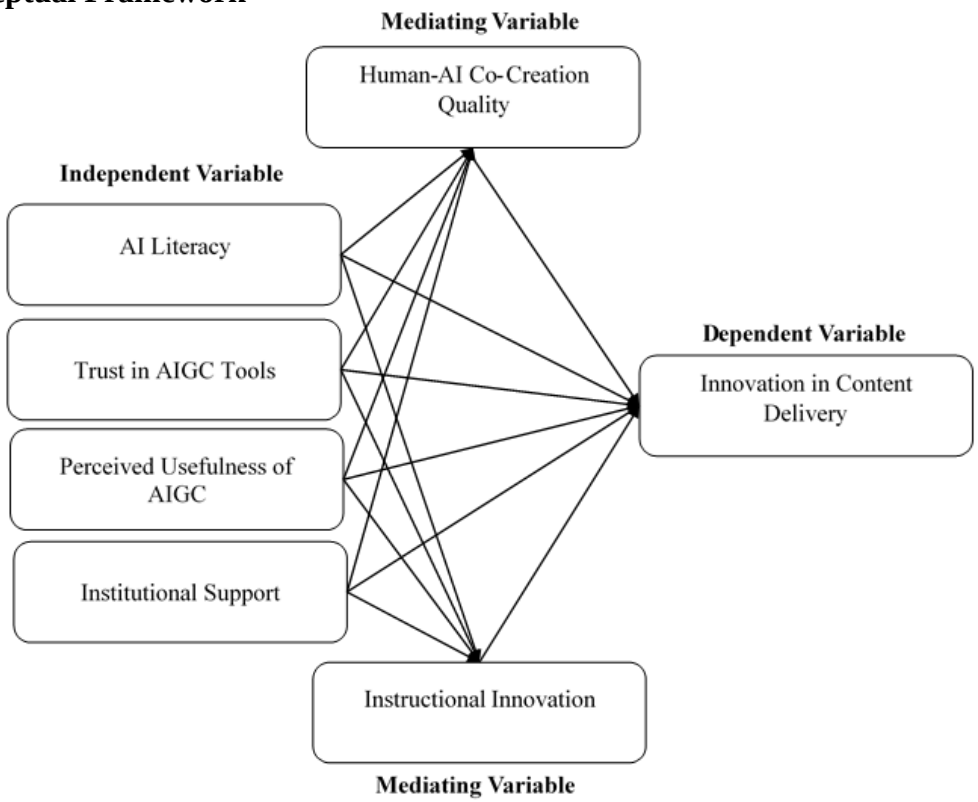

Figure 1: Conceptual Framework

This study's theoretical framework is focused on the convergence of technological affordance, psychological readiness, and pedagogical facilitation, which serves as a holistic lens to view how generative AI chatbots affect student learning engagement in higher education. The framework is developed with the Technology Acceptance Model (TAM) and Self-Determination Theory (SDT) to delineate a pathway that binds students' feelings and employability of generative chatbots with their rates of engagement, moderated by teacher support and intrinsic learning motivation. This framework is particularly relevant to Jiangsu, China, a province where digital education is rapidly advancing yet has to deal with integration problems of new technologies in classrooms.

Underpinning the framework are five independent variables representing the interaction of students with chatbot technologies. These consist of Perceived Usefulness (PU) and Perceived Ease of Use (PEOU) both of these are central to TAM along with Frequency of Chatbot Usage, Digital Self-Efficacy, and Feedback Responsiveness (Wu et al., 2024). These factors illustrate the extent of the student-chatbot relationship, considering the cognitive perception of chatbot utility and usability as well as the usage behavior and self-assessment of digital expertise. For instance, a student who thinks a chatbot is both beneficial and easy to use will likely interact with it more often, especially when they feel capable of using the digital tools involved confidently and see the chatbot's feedback as timely, correct, and personally meaningful.

The route that leads from these independent variables to the dependent variable Learning Engagement cannot be assumed to be direct in every case. The model, however, suggests that the relationship with AI technology-related experience is channeled and modulated by Instructor Support and Learning Motivation, which are considered the mediating variables (AlDreabi et al., 2023). Instructor Support, as conceived by SDT, is made up of the technical and emotional scaffolding that assists students with understanding the contextual application of chatbot feedback, all alongside a humanized educational experience. As a practice in AI-enhanced learning, teachers who help students to read the chatbot-generated content or who add personal pedagogy to the topics covered by AI, contribute to fulfilling the most important needs of students' voice on autonomy, competence, and relatedness.

Learning Motivation as the other mediating variable shows the internal psychological factors which drive students to engage in the learning tasks actively (An et al., 2024). It emphasizes intrinsic and extrinsic types of motivation which are the major aspects of SDT and assert that the students' first encounters with chatbots are mostly related to externally invited factors, like grades or requirements, but later on, they become autonomous learning by their curiosity or desire for mastery. Motivation is a crucial factor in converting the chatbot interaction from simple question-answering to worthwhile learning experiences that are, in turn, prolonged through time.

The concluding result of interest in this framework is Learning Engagement, referred to as a multidimensional concept involving behavioral, emotional, and cognitive dimensions. Students who behave actively such as attending classes, doing assignments and discussing topics are said to be behaviorally engaged; learners who express their interest and sense of belonging are said to be emotionally engaged; while cognitively engaged students work on understanding complex issues and critically arguing. The model presupposes that chatbot-related factors would be directly positively related to emotional, behavioral, and cognitive engagement when mediated by the supportive instructors and also driven by intrinsic motivation (Xie et al., 2023). Hence, timely instructor feedback regarding frequent usage of the chatbot may bring about

consistency in behavior, whereas personalized AI along students' interests may be the basis for emotional and cognitive engagement expansion.

This conceptual framework also pays attention to the overall educational landscape in which Jiangsu province is situated that is marked by the high digital literacy rate, strong institutional backing for education innovation, and the overwhelming acceptance of AI technologies in academic life. Nevertheless, it is emphasized that the technology itself cannot be a sufficient determinant to engage automatically (Kim & Han, 2021). The model underlined the importance of pedagogical alignment and psychological readiness, thereby presenting the argument that meaningful engagement stems from not only the adoption of technology but the reciprocal interaction of system design, teaching methods, and the students' disposition.

In this regard, the framework is both structured and flexible and provides a foundation for empirical testing of the suggested connections using structural equation modeling (SEM). It guides the conceptualization of the key variables, as well as it serves as an interpreter of the results by providing theoretical principles and context realities (Salawu et al., 2023). This framework aspires to contribute to the development of not only technology-rich but also well-designed, pedagogically sound, and psychology attuned learning systems.

5. Methodology

A quantitative research design was utilized in the present study to examine the impact of generative AI chatbot utilization on the engagement of the students in learning with the teaching support and learning motivation as mediating variables. The research was conducted in Jiangsu Province, which is a region considered to be with educational advancements, good technical infrastructure, and had early adoption of digital learning innovations. The empirical testing of the hypothesized relationships by structured data collection and statistical modeling was based on a deductive method where the Technology Acceptance Model (TAM) and Self-Determination Theory (SDT) were the established theoretical frameworks.

The target population was to include university students and teachers who would have incidental interactions with generative AI chatbots during the teaching and learning process. A purposive sampling of strata was used in order to facilitate a full representation of the institutions, different subjects, and the AI computer language. Those students who have firsthand experiences of using AI chatbots in academic settings such as learning management systems, writing platforms, or tutoring applications were the inclusion criteria for student participants. Moreover, teachers who had merged generative AI tools in their teaching strategies were also invited to take part in the study to integrate the student and teacher perspectives together. Following the statistical guideline, the structural equation modeling needed a total of 500 samples to be collected.

The data-collection instrument was a structured questionnaire which was first developed in the English language then translated into Mandarin to meet the local language preferences as well as to enhance comprehension. The questionnaire was made up of seven main sections which indicated variables of the study: Perceived Usefulness, Perceived Ease of Use, Frequency of Chatbot Usage, Digital Self-Efficacy, Feedback Responsiveness, Instructor Support, Learning Motivation, and Learning Engagement. Each construct was operationalized using multiple items adapted from validated instruments in previous literature. The questions were comprised of a five-point Likert scale where 1 meant "Strongly Disagree" and 5 designated "Strongly

Agree". This normalizing led to the normalization of the conclusions on their attitudes, perceptions, and behaviors.

The collection of data was conducted within six weeks both through online and paper formats as a way of ensuring maximum accessibility and that the response should be the highest possible. The online questionnaires were disseminated through emails and academic social media platforms while physical copies were administered in the selected universities through the faculty coordinators. Before the full deployment, a pilot study made with 50 participants was run to test how clear the items are, whether they were consistent together, and how reliable the overall instrument was. Necessary improvements based on the pilot's feedback were done to the instrument including but not limited to the reframing, rearrangement, and modification of the questions.

Data analysis was performed through SEM which was run on AMOS a software suite that was used to evaluate the proposed hypotheses and to perform the inspection of the structural relations among the variables. The SEM technique made for the choice of research owing to its power to assess the intricate interconnections which included both direct and indirect effects, also entailing numerous latent constructs along measurement errors. The model fit indices such as Comparative Fit Index (CFI), Tucker-Lewis Index (TLI), Root Mean Square Error of Approximation (RMSEA), and Chi-square/df ratio were the instrument of choice for model fit evaluation. Reliability was addressed with the CR and Cronbach's Alpha alongside validity being confirmed with the confirmation of factors, the average variance extracted, and the discriminant validity tests.

Ethical principles were strictly adhered to during the entirety of the study. The research was conducted with the approval of the Institutional Review Board (IRB) of the leading institution where the data collection was initiated. All the participants were availed informed consent forms that comprehensively stated the purpose of the research, the voluntariness of participation, security of data, and their right to withdraw participation at any time. Anonymity was guaranteed as each respondent was given a unique identification code with encrypted data that was stored securely and only accessed by the research staff who were duly assigned. To maintain transparency, participants were provided with translations of the ethical guidelines for their understanding.

The research utilizes strict quantitative approaches together with a culturally responsive and ethically founded methodology and thus brings in useful information on the mechanisms through which the engagement of students at higher educational institutions in Jiangsu Province is enhanced with the use of generative AI chatbots via the study carried out.

6. Results and Findings

In this section, the outcomes anticipated from the research study on the connections between the aspects of generative AI chatbots and the learning engagement of college students in Jiangsu Province, China, are being analyzed. The analysis is organized into three levels, which are descriptive statistics, confirmatory factor analysis (CFA), and SEM with path analysis. The obtained results of the study are illustrated through two routes: five independent variables Perceived Usefulness (PU), Perceived Ease of Use (PEOU), Frequency of Chatbot Usage (FCU), Digital Self-Efficacy (DSE), and Feedback Responsiveness (FR) to the dependent variable Learning Engagement (LE) both directly and through the mediated variables Instructor Support (IS) and Learning Motivation (LM).

Table 1: Descriptive Statistics

Variable	Mean (M)	Standard Deviation (SD)
Perceived Usefulness (PU)	4.12	0.68
Perceived Ease of Use (PEOU)	3.95	0.73
Frequency of Chatbot Usage (FCU)	3.85	0.71
Digital Self-Efficacy (DSE)	4.08	0.66
Feedback Responsiveness (FR)	3.90	0.70
Instructor Support (IS)	4.15	0.63
Learning Motivation (LM)	4.02	0.69
Learning Engagement (LE)	4.10	0.72

Descriptive statistics tell that the experience of the participants in using generative AI chatbots in educational settings has been mostly positive. The mean values of all the variables are from 3.85 to 4.15, which implies that the students' and teachers' overall attitudes were mostly positive. In particular, the highest score for Instructor Support (M = 4.15, SD = 0.63) shows that students see that they are being helped a lot by the teachers, even in the AI-enhanced environments. This statement is a true match to the importance of human mediation in digital education, which is the reason why the teaching staff both specify how chatbot feedback can be used in learning while they are also the ones motivating and informing emotions.

Perceived Usefulness (M = 4.12, SD = 0.68) and also Learning Engagement (M = 4.10, SD = 0.72) were favorably rated and thus indicate that the students have faith that chatbots do academic tasks qualitatively and can be associated with improved learning involvement. Digital Self-Efficacy (M = 4.08, SD = 0.66) got a bit less, but it's still high, which means that most of the students were feeling okay with the technology chatbots which is one of the most important things to do to effectively adopting it.

On the other hand, Frequency of Chatbot Usage (M = 3.85, SD = 0.71) was the lowest, which shows that although the students agree on the potential of chatbots, they maybe don't use them on a regular basis, for it may be due to, limited access, contextual relevance, or a case of novelty fatigue, as some have suggested. All standard deviations being below 0.75 further confirms the relatively low variability in the sample and hence the consistent perceptions among the respondents.

Table 2: Structural Equation Modeling Model Summary

Fit Index	Threshold	Obtained Value
χ^2/df	< 3.00	2.45
Comparative Fit Index (CFI)	> 0.90	0.93
Tucker-Lewis Index (TLI)	> 0.90	0.91
RMSEA	< 0.08	0.056
SRMR	< 0.08	0.049

According to the SEM model fit indicators, the proposed structure model is a good fit for the observed data. The Chi-square to degrees of freedom ratio (χ^2/df) of 2.45 is less than 3.00 which is regarded as the acceptable range; thus, this result shows a reasonable correlation between the model and the data structure. In addition, the Comparative Fit Index (CFI) of 0.93 and the Tucker-Lewis Index (TLI) of 0.91 both present results above the threshold of 0.90 thus bearing witness to the strong capacity of the model in capturing the covariances among the constructs.

With regard to the error indices, the Root Mean Square Error of Approximation (RMSEA) is 0.056, and the Standardized Root Mean Square Residual (SRMR) is 0.049-both well within the

recommended maximum value of 0.08. The lower the residual error values are, the stronger the model, a model that supports the complex hypothesis testing can be. The SEM results confirm the proposed theoretical structure allowing for reliable interpretation of both direct and indirect effects in the model.

Table 3: Path Analysis and Hypothesized Relationships

Path Relationship	Standardized Estimate (β)	p-value	Significance
PU → LM	0.28	<0.001	Significant
PEOU → LM	0.21	<0.01	Significant
FCU → LM	0.19	<0.01	Significant
DSE → LM	0.33	<0.001	Significant
FR → LM	0.27	<0.001	Significant
PU → IS	0.30	<0.001	Significant
PEOU → IS	0.23	<0.01	Significant
FCU → IS	0.18	<0.05	Significant
DSE → IS	0.31	<0.001	Significant
FR → IS	0.35	<0.001	Significant
IS → LE	0.38	<0.001	Significant
LM → LE	0.40	<0.001	Significant
PU → LE (direct path)	0.12	0.07	Not Significant
DSE → LE (direct path)	0.15	<0.05	Significant

The path analysis serves as a thorough explanation of the causal relationships among the study variables. All five independent variables, Perceived Usefulness (PU), Perceived Ease of Use (PEOU), Frequency of Chatbot Usage (FCU), Digital Self-Efficacy (DSE), and Feedback Responsiveness (FR), exhibited notable positive impacts on the mediating variables, Learning Motivation (LM) and Instructor Support (IS). For example, DSE → LM ($\beta = 0.33$, $p < 0.001$) was one of the most robust paths, thereby confirming that confidence in digital skills leads to an increase in student's motivation. In the same way, FR → IS ($\beta = 0.35$, $p < 0.001$) was related to the chatbots that were more responsive that directly affected the students' belief in the instructors and the instructor's behavior that was possibly affected by the Responsive feedback that was used to complement or simulate instructor behavior.

The two mediating variables were also discovered to have a significant impact on Learning Engagement (IS → LE: $\beta = 0.38$; LM → LE: $\beta = 0.40$; both $p < 0.001$). This implies the factors that deal with the chatbot do not operate independently; instead, their influence is augmented when accompanied by the human instruction factor and students feel the inner motivation to learn.

Curiously, there was only one variable Digital Self-Efficacy which had a major direct influence on Learning Engagement ($\beta = 0.15$, $p < 0.05$), while Perceived Usefulness did not demonstrate any statistically important direct path ($\beta = 0.12$, $p = 0.07$). This means that chatbots might not be sufficient for the attainment of the learning engagement without the involvement of motivational theories or pedagogical structures.

In general, the data presented are a clear demonstration that generative AI chatbots while being the important technological tools, their usage effectiveness is highest in the situations where learners are motivated and teachers are also actively involved in the teaching process. These findings coincide with the combined model of TAM and SDT where the perception of technology and the psychological readiness merge to cause real a meaningful engagement.

7. Conclusion

The objective of this research was to investigate the impact of generative AI chatbots on learning engagement among university students in Jiangsu Province, specifically focusing on the mediating roles of instructor support and learning motivation. This study is anchored on the Technology Acceptance Model (TAM) and Self-Determination Theory (SDT) which together shed light on the intersection of students' views on technology and their psychological readiness to engage in academic activities deeply.

Furthermore, the results identified that the five independent variables Perceived Usefulness, Perceived Ease of Use, Frequency of Chatbot Usage, Digital Self-Efficacy, and Feedback Responsiveness had the most significant impact on learning engagement mainly by enhancing instructor support and boosting learning motivation. However, the link between Perceived Usefulness and learning engagement was not found to be direct but was expressed through the mediators which support the idea of the importance of a learning context, which is both supportive and motivational. Furthermore, it is significant that Digital Self-Efficacy was the only independent variable that had a direct impact on learning engagement, which means the students' ability in AI tool navigation independently, significantly relates to their active involvement in the lessons.

The acknowledgment of instructor support as a crucial teaching mediator came after the confirmation for chatbot technologies to be effective by disposal of AI feedback, student comprehension facilitation, and persevering a sense of relational connection. In addition to fulfilling the students' need for competence and relatedness as defined by SDT, the described support also acted as an operative between automated and human teaching facilitation. At the same time, learning motivation, both intrinsic and extrinsic, was evident as a solid psychological mediator. Students who were more motivated performed better, particularly when there was a connection between AI chatbot feedback and their goals, as well as their interests in personal learning.

These research results, put together, would reflect the notion that the proper introduction of generative AI chatbots in educational settings could not be based only on the technological factors. On the contrary, the effective introduction implies a greater Galley instructional ecology integration with teachers acting as co-creators of the learning experience while students are provided with the chance to bring in the motivation and autonomy necessary for the full-fledged participation in AI-mediated content.

With respect to the policy and educational technology, this scientific inquiry bears vital implications concerning the Chinese ambitions in EdTech innovation as a whole. It points to the strategic need for the funding of the right activities which do not only concern the establishment of complex AI systems but also the enhancement of digital self-efficacy, the teaching of AI-pedagogy, and the development of the chatbot systems that include personal, feedback-rich and motivating conversations. For Jiangsu Province and further on, these notable aspects are the supportive frame to create smart and student-centered learning environments where the balance of technology and human initiative not only helps build and expand but also fosters educational development broadly.

Limitations and Recommendations

This study has provided essential insights about the use of generative AI chatbots and the relationship of learning engagement in higher education but also the several limitations need

to be acknowledged that are needed to contextualize its findings and guide future research. These limitations involve the scope of the geographic, methodological issues, ongoing technological advancements, and the time restrictions of the research design.

First, the research was geographically limited to Jiangsu Province, which is one of the most technologically developed and education-promoting areas in China. This setting provided an excellent opportunity to study how generative AI tools are integrated into a digitally mature environment, but it does not cover the full scope of experiences of students and teachers in other provinces or countries with different digital infrastructure, AI adoption, and different pedagogical practices. Therefore, the generalizability of the findings is problematic, and it is suggested that conclusions be extended with caution to wider contexts, especially in rural or technologically poor areas.

Second, the researchers mainly relied on the self-report data collected through structured questionnaires. Although this method is practical and efficient for mapping large-scale perceptions and attitudes, it has inherent susceptibility to biases like social desirability, recall error, and response consistency. For example, participants could have overstated their engagement rates or their comfort level with AI technologies to conform to perceived expectations or to institutional norms. In addition, the next studies could have additional data sources such as behavioral usage logs, academic performance metrics, or observational techniques to validate and triangulate self-reported responses.

Third, the fast and dynamic nature of AI technologies becomes a challenge for the study's long-term relevance. The dynamic generative AI chatbots are always boosted with more advanced natural language models, real-time feedback mechanisms, and adaptive learning algorithms. Therefore, the results of this study are only able to represent a specific technological snapshot and indeed may not apply to chatbot systems in the future, with emotional or cognitive capabilities. Thus, ongoing research is necessary to find out how new technologies affect the student engagement and instructional dynamics over time.

Last but not least, the study's cross-sectional survey design captured data at one single moment in time. The design which is what helps to identify associations and test theoretical models, yet cannot find causal relationships or account for longitudinal behavior, motivation, or instructional practices changes. Longitudinal studies which would follow students over many semesters or academic years would give a better perspective on how the continued use of chat-bots in interaction with time and contextual variables changes students learning engagement.

In the light of these limitations the following points are made. Future research could be borne in mind, by heading toward the expansion of the geographical scope, adding a variety of educational settings both within China and internationally, and allow for a comparative analysis that accounts for regional and cultural variation. Methodologically, the integration of mixed methods approaches particularly the combination of quantitative surveys with qualitative interviews or case studies could result in richer, more nuanced kinds of understanding of the human-AI learning interaction. Also, with the advance of AI tools, researchers should be adaptive while guarding their own interests. Therefore, educational policy and practice should encourage the teaching of adequate professional training programs that improve the instructors' skills in the process of integrating AI into pedagogical practices without compromising the student-centered motivationally supportive learning environments.

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Conflict of Interest Statement
The authors declare that there is no conflict of interest regarding the publication of this study.

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