THE IMPACT OF INNOVATIVE TEACHING METHODS ON STUDENTS' LEARNING ENGAGEMENT: THE MEDIATING ROLE OF MOTIVATION AND THE MODERATING EFFECT OF DIGITAL LITERACY

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Abstract: This study takes students' learning engagement as the dependent variable, innovative teaching methods as the independent variable, constructs a conceptual model that includes demographic variables such as gender, age, grade, major, and grades, analyzes the cognitive differences in teaching perception and learning engagement between different groups, and examines the predictive effect of teaching innovation on learning engagement. This study proposes the following hypotheses: H1: Innovative teaching methods have a significant positive impact on students' learning input. H2: Student motivation plays a mediating role between innovative teaching methods and learning input. H3: Digital literacy moderates the impact of innovative teaching methods on students' learning input, and students with high digital literacy have stronger input. The study used college undergraduates as the sample, adopted a stratified random sampling method, determined the sample size to be 483, distributed a total of 500 questionnaires, and recovered 483 valid questionnaires, for a recovery rate of 96.6%.

This study found that innovative teaching methods have a significant positive impact on students' learning engagement; that student motivation plays a mediating role between innovative teaching methods and students' learning engagement; and that digital literacy does not significantly moderate the impact of innovative teaching methods on students' learning engagement. This study deepens the application of self-determination theory and constructivism in the field of college teaching innovation, and provides practical guidance and theoretical basis for future curriculum design and motivation strategies.

Keywords: Innovative Teaching Methods, Students' Learning Engagement, Motivation, Digital Literacy

Introduction

As higher education continues to evolve globally, the accelerating convergence of digital transformation and pedagogical innovation is driving profound changes in teaching models, learning methods, and curriculum structures. Traditional teacher-centered, didactic teaching is gradually being replaced by new teaching paradigms that are more dynamic, student-centered, and integrated with technology, such as the flipped classroom, project-based learning, gamification, and blended learning environments. The core of these teaching innovations is to enhance students' cognitive engagement, stimulate their learning autonomy, and ultimately optimize learning outcomes (Alonso, Morales-Contreras, & Romero-Rodríguez, 2023).

This trend of change is particularly prominent in the post-COVID-19 normalcy of education. The pandemic has not only broken the temporal and spatial boundaries of offline classrooms, but has also prompted universities to institutionalize online and blended teaching as a normal teaching mechanism. However, the effectiveness of teaching innovation varies significantly among different groups of students. A key issue behind this is that these methods are not equally effective for all students. Previous studies have pointed out that the effectiveness of implementing teaching innovation largely depends on two core psychological variables: students' learning motivation and digital literacy. However, these two factors have often been treated separately in previous studies, lacking the support of a systematic and integrated mechanism model (Bustamante-Mora, Fernández-Martínez, & Gallego-Arrufat, 2023).

Learning engagement, as a key variable that measures the cognitive, affective, and behavioral engagement of students in academic activities, has long been considered an important predictor of academic success, sustained learning, and course satisfaction (Fredricks, Blumenfeld, & Paris, 2004). Although a large body of literature has confirmed its close relationship with motivation, self-efficacy, and learning autonomy, empirical studies on how instructional innovation affects student engagement through “motivating factors” and is moderated by digital literacy in the process are still scarce. More critically, most existing studies still focus on Western education systems. For non-Western contexts, especially educational situations in developing countries, the impact of students' technological capabilities and psychological structures on the mechanism of instructional innovation has not been systematically examined.

This research gap is particularly prominent in the context of higher education. Despite strong advocacy for digital education and classroom innovation at the policy level (e.g., Ministry of Education, 2020), college students generally experience low intrinsic motivation, technology anxiety, and poor platform adaptability when dealing with learning modes such as flipped classrooms, independent projects, and collaborative platforms (Do, Nguyen, & Nguyen, 2023). If the interactive mechanism between teaching strategies, students' psychology, and technological literacy cannot be identified and understood, teaching reform will be unable to achieve its threefold goal of fairness, personalization, and

high-quality development.

In order to effectively explain this complex mechanism, this paper introduces two classic educational psychology theories—Self-Determination Theory (SDT) and Constructivist Learning Theory—to jointly construct a theoretical framework for the study. The former was proposed by Deci and Ryan (1985, 2000), who believe that there is a "intrinsic motivation-extrinsic motivation" continuum in human learning motivation, and that the degree to which the learner's three psychological needs of "autonomy, competence and relatedness" are met is the core factor that determines their motivation level and sustained learning behavior (Ryan & Deci, 2017). The latter theory asserts that learning is not a passive process of receiving information, but rather an active construction process formed by students through interaction with real-world situations, task exploration, social collaboration and reflection (Jonassen, 1999).

Integrating these two theoretical perspectives can provide a strong basis for a deeper understanding of the influence path between "teaching strategies-psychological motivation-learning behavior." Taking strategies such as the flipped classroom, gamified learning, and project-based tasks as examples, their essence lies in constructing a learning environment that supports student autonomy and situational engagement, thereby stimulating their intrinsic motivation and improving cognitive investment and behavioral sustainability. However, this path does not hold in all situations, and one of the key factors that interfere with it is the level of students' digital literacy.

Digital literacy is a comprehensive ability structure that not only includes technical operation ability, but also covers multiple dimensions such as information acquisition, content evaluation, collaborative interaction, and digital citizenship awareness (Ng, 2012; Eshet, 2012). It is far from simply "technical proficiency" and is a key prerequisite for learners to effectively participate, think, and create in a digital environment (Belshaw, 2011). Research shows that differences in digital literacy are often influenced by factors such as socioeconomic status, access to educational resources, and learning experiences, resulting in a "second digital divide" (Zilka, 2021).

In this study, digital literacy is considered a contextual moderator. Students with high levels of digital literacy are more likely to adapt to innovative teaching environments and to leverage the full potential of online platforms, collaborative tools, and feedback mechanisms, resulting in stronger learning motivation and engagement. Students with lower digital competence may experience anxiety, rejection, or even disruption to their learning. Therefore, introducing digital literacy into the instructional mechanism model not only improves the model's contextual adaptability, but also reveals educational inequalities in the digital transformation process.

Although there has been an increasing amount of research on pedagogical innovation in recent years, there is still a lack of solid empirical evidence to support the key question of "how" and "under what conditions" innovative strategies can truly motivate students' learning engagement. Vélez et al. (2023) pointed out that current educational research has focused on the explicit structure of teaching

methods, ignoring the synergistic effect of implicit variables such as students' individual psychological motivation and digital competence. It is in this research gap that this paper proposes a dual path model of mediation and regulation, hypothesizing that

Teaching innovation indirectly enhances students' learning engagement by activating their intrinsic motivation (mediation effect);

digital literacy affects the strength of the above path, that is, teaching strategies are more likely to be effective when digital competence is high (moderation effect).

This study focuses on college students in particular, exploring the interactive mechanism between their perception of innovative strategies, motivational response and behavioral engagement in the context of actual teaching reform. It attempts to answer the following key questions:

Under what psychological motivation and technological literacy conditions can teaching innovation strategies truly promote students' learning engagement?

The primary objective of this study is to construct and verify the mediating path between "teaching innovation-motivation-learning input" and further examine the moderating effect of digital literacy in this path. Specifically, this paper will:

clarify the direct effect of teaching innovation on student learning input; reveal the transmission mechanism of internal and external student motivation in this path;

explore how digital literacy affects students' adaptation to and feedback on teaching strategies; provide refined data-based strategy support for college teaching design; and respond to the current three major policy issues of educational equity, technology integration, and student engagement.

This research has theoretical and practical value in the following three areas:

Theoretical innovation: Integrating SDT and constructivist theory, a replicable and extensible learning mechanism model is proposed, enriching the theoretical perspective of interdisciplinary research in educational psychology and instructional design.

Practical guidance: Providing actionable strategies to help teachers accurately configure teaching methods under the digital competency structure of different students and improve teaching adaptability.

Policy implications: Provide empirical support for promoting "digital education equity" and "teaching capacity building" at the national level, and promote the realization of the United Nations' "Sustainable Development Goals for Education (SDG 4)" (UNESCO, 2019).

Research Objectives

This study aims to explore the role path of how innovative teaching methods affect students' learning engagement in the context of the digital transformation of higher education, through the mediating mechanism of students' learning motivation and the moderating condition of digital literacy. Focusing on the specific cultural and educational context of Chinese college students, the study will

systematically analyze the internal correlation mechanism between students' perception of teaching innovation, their psychological motivation and actual behavioral engagement, and reveal whether teaching reform can achieve its core goal of "student-centered and participation-oriented" in real classroom situations.

With the trend of constantly innovating teaching methods, understanding the psychological and technical conditions that truly promote student participation has become a key issue that educational theory and practice must face. This study constructs a research framework based on self-determination theory and constructivist learning theory, and attempts to fill the theoretical and empirical gaps in existing research, such as "unclear mechanisms", "unclear paths of action", and "cultural adaptability to be verified".

The overall objective of this study is to construct and verify a mediation model with "teaching innovation → learning motivation → learning engagement" as the core path and "digital literacy" as the moderating variable. Through this model, the following core issues are clarified:

1. Can teaching innovation effectively stimulate students' learning motivation?
2. Can motivation activation be translated into higher levels of learning engagement?
3. What amplifying or inhibiting role does digital literacy play in the above path?

Specifically, the study hypothesizes that when students are in a highly autonomous and technology-supported teaching environment, their intrinsic motivation level will increase significantly, and they will show more positive learning engagement in multiple dimensions of cognition, emotion and behavior. The level of students' digital literacy skills will affect the effect of teaching innovation on motivation and behavior transformation.

Focusing on the above core issues, this study aims to achieve the following five specific research objectives:

Objective 1: Examine the direct impact of innovative teaching methods on students' learning engagement

This objective aims to empirically analyze whether students' learning engagement in the three dimensions of cognition, emotion and behavior significantly improves when they participate in innovative teaching activities such as flipped classrooms, project-based learning, and gamified tasks, revealing the direct causal relationship between teaching methods and student participation.

Objective 2: Analyze the mediating role of students' learning motivation between teaching innovation and learning engagement

Based on self-determination theory, this objective explores in depth how students' intrinsic motivation (e.g., autonomous drive, interest orientation) and extrinsic motivation (e.g., task achievement, evaluation incentives) play a mediating role in the psychological mechanism between teaching strategies and learning behaviors after receiving innovative teaching.

Objective 3: Explore the moderating role of digital literacy in the relationship between teaching

methods and learning engagement

This goal constructs digital literacy as a contextual variable and analyzes whether there are significant differences in the paths of the effects of teaching methods on motivation and learning engagement at different levels of digital competence. In particular, it is investigated whether highly-literate students can make better use of the resources and experiences brought about by teaching innovations.

Objective 4: Assess the impact of demographic variables on model variables

This study will control and examine whether demographic variables such as student gender, grade, major type, and GPA have a significant moderating or interfering effect on the path relationships in the research model, ensuring that the model has sufficient control validity and broad adaptability.

Objective 5: Propose recommendations for optimizing teaching strategies based on empirical data

Ultimately, this study will propose feasible teaching improvement paths based on empirical models, especially for student groups with insufficient motivation activation or weak digital literacy, and provide targeted teaching support strategies to provide practice-oriented decision-making references for college teachers, curriculum designers, and education administrators.

Literature Review

Against the backdrop of the gradual digitalization, intellectualization and personalization of higher education around the world, innovative teaching methods have gradually become the core path to improving teaching quality and learning outcomes. In particular, after the “student-centered” teaching concept has become increasingly mainstream, traditional lecture-based teaching faces many challenges. Its efficiency of knowledge transfer, level of interaction, and student engagement all need to be improved urgently. In this context, innovative teaching strategies such as Flipped Classroom, Project-Based Learning (PBL), and Gamification have received widespread attention.

The introduction of innovative teaching methods is a positive response to the changing environment of higher education in the 21st century. In an era that emphasizes learner autonomy, collaboration, digital literacy, and lifelong learning skills, traditional lecture-based teaching methods can no longer meet educational needs. Unlike traditional teaching methods, which are teacher-centered and students passively receive knowledge, innovative teaching methods place more emphasis on student-centered, active participation, and real-world task-driven learning experiences, often incorporating digital technology, cooperative learning, and interdisciplinary problem solving. Innovative teaching methods essentially stem from Constructivist Learning Theory. This theory asserts that learning is a process in which students actively construct knowledge rather than passively receive information. Jonassen (1999) pointed out that truly effective teaching should create real problem situations, provide opportunities for collaboration, and promote the application of knowledge, thereby

stimulating students' active exploration and internalized understanding. This concept has become the theoretical backbone of innovative teaching design, guiding teachers to transform from “transmitters” of knowledge to “guides” and “facilitators” of learning.

The core idea of the flipped classroom, for example, is to shift the knowledge transfer to pre-class self-study, and the classroom is used for collaborative discussion and problem solving. A systematic review by Bishop and Verleger (2013) shows that this model helps to improve students' classroom participation and self-directed learning ability, and is especially suitable for types of courses that emphasize knowledge application and critical thinking. Empirical studies have also confirmed that flipped classrooms can significantly improve learning outcomes and student satisfaction (Gilboy et al., 2015; Lo & Hew, 2017).

Project-based learning (PBL) places more emphasis on students completing interdisciplinary projects in real or simulated tasks. In the process, they need to collect data, design plans, collaborate and form results to be displayed. This method not only improves students' problem-solving and teamwork skills, but also strengthens the integration of knowledge and practice (Pessoa et al., 2021). Project-based learning is highly consistent with Dewey's (1938) concept of “learning by doing,” which emphasizes experience-oriented and contextual learning.

Gamification is a new strategy driven by technology in recent years that uses game elements such as points, badges, and leaderboards to stimulate students' intrinsic motivation. Deterding et al. (2011) define it as the application of game mechanics to non-game contexts to enhance the user experience. In teaching, gamification not only makes learning more interesting, but also satisfies students' psychological needs for autonomy, achievement, and social interaction, in line with the basic psychological needs structure proposed by Self-Determination Theory (SDT) (Deci & Ryan, 2000).

Although the above-mentioned innovative teaching methods have shown good application prospects in various studies, some scholars have pointed out that if the technical capabilities, motivational foundations, and learning preferences of students are not fully considered, the results may be counterproductive. Carella and Colombo (2024) emphasize that it is difficult for method updates alone to truly translate into changes in learning behavior, and that an “adaptive teaching system” based on students' cognitive structures and ability foundations needs to be constructed.

The issue of motivation accounts for a large part of our research. Researchers have conducted extensive studies on learner motivation for decades. Atkinson (1964) believes that motivation is used to describe the factors that stimulate a person's enthusiasm and guide the direction of activities, and that energy and direction are at the heart of motivation. Gardner and his colleagues' (1985) research has greatly influenced motivation research in second language acquisition. They explain motivation as a combination of effort and desire to work towards learning language goals, as well as a positive attitude towards learning. When people pursue a goal, effort, desire, and a positive attitude towards life are always the path to success. Learning becomes interesting when we desire to achieve a goal. If learning

is just a burden, then people will lack motivation. Gardner (1985) also believes that learning motivation is influenced by two language learning orientations: integrative and instrumental. Crookes and Schmidt (1991) believe that motivation is a more complex concept, especially in different environments for foreign language learning. In addition, Crookes and Schmidt (1991) incorporated the external and behavioral characteristics of language learning into the research of previous researchers. In short, motivation is a complex concept. According to Ellis (1994), motivation refers to the efforts made by learners out of their needs and desires to learn a foreign language. It plays an important role in foreign language acquisition. As a bridge connecting teaching design with student learning behavior, learning motivation is one of the core variables in current educational psychology research. It not only determines whether students participate in learning, but also deeply influences the depth, persistence and strategy of learning. Motivation is usually divided into intrinsic motivation and extrinsic motivation. In recent years, theories that emphasize the "quality" rather than the "intensity" of motivation have gradually become mainstream.

Among the many theoretical models, self-determination theory (SDT) proposes that the three basic psychological needs of humans – autonomy, competence, and relatedness – are widely used to explain the motivational generation mechanism (Deci & Ryan, 1985). When the learning environment can meet these three needs, students are more likely to have high-quality intrinsic motivation, and in turn, show greater persistence and engagement in learning (Ryan & Deci, 2000).

This mechanism is particularly important in the application of innovative teaching methods. For example, the flipped classroom provides students with the choice of learning path and time, satisfying their need for autonomy; the achievement of project-based tasks enhances students' sense of competence; and the interactive process of collaborative learning enhances their relationships. Chen and Jang (2010) found that students' motivation increased significantly when they perceived high autonomy support in the instructional design.

More importantly, a number of empirical studies have shown that motivation plays a significant mediating role between teaching methods and learning engagement. Kusurkar et al. (2013) found in their study in the field of medical education that the teaching method itself does not directly improve student performance, and the key is whether it can stimulate students' autonomous motivation. Sun et al. (2023) further confirmed that in an online learning environment, motivation not only affects the frequency of participation, but also determines whether students can persist in completing the course.

In an educational environment with a high degree of technology penetration, digital literacy has gradually become a key factor affecting whether students can adapt to and benefit from teaching innovations. Digital literacy not only refers to the ability to operate technical tools, but also includes multi-dimensional abilities such as information identification, online collaboration, content creation, digital security and ethical judgment (Ng, 2012).

The DigComp 2.1 framework proposed by the European Union divides digital competence into

five major areas: information processing, online communication, content creation, security awareness, and problem-solving skills (Vuorikari et al., 2016), emphasizing that digital literacy is a comprehensive civic competence. In higher education, whether students have sufficient digital literacy will directly determine whether they can effectively use the learning management system (LMS), participate in online discussions, and complete multimodal tasks.

Studies have generally found that students with higher levels of digital literacy have stronger self-discipline, higher engagement, and better learning outcomes (Hong et al., 2014; Ahmad et al., 2024). On the contrary, students with weaker digital literacy often feel technical barriers and anxiety when facing innovative designs such as gamification platforms, project-based tasks, and flipped teaching, which in turn leads to learning avoidance behaviors.

At the mechanism level, digital literacy is likely to have a moderating effect between "teaching methods" and "motivation/engagement". Zainuddin et al. (2024) conducted an empirical study and found that in the same flipped classroom context, students with strong digital skills significantly outperformed the low-skill group in terms of motivation, self-efficacy, and engagement, indicating that the effect of instructional design is significantly affected by the boundary conditions of digital literacy. Wildani and Budiyono (2024) proposed the phenomenon of "digital exclusion" pointing out that the digital divide is no longer a question of whether or not one has access to equipment, but rather a deep-seated inequality in terms of whether or not one can effectively use and benefit from it. This is known as the second-level digital divide (van Deursen & van Dijk, 2014).

Therefore, digital literacy is not only a technical variable, but also an "enabling condition" that determines whether or not teaching innovations can truly reach students and be transformed into learning momentum.

Learning engagement is an important indicator of teaching effectiveness and plays a central role in educational research. Fredricks, Blumenfeld and Paris (2004) divide it into three dimensions: behavioural engagement (e.g. attendance, participation, task completion), affective engagement (e.g. interest, sense of belonging, satisfaction) and cognitive engagement (e.g. deep processing, strategy use, metacognitive regulation).

Many studies have shown that learning engagement is not only a key variable affecting academic performance and course completion rates, but also an effective indicator of teaching quality and student well-being (Kahu, 2013). Astin's (1984) "engagement theory" states that the more time and mental energy students invest in the learning process, the more significant their learning outcomes will be. In recent years, with the rise of online learning and blended teaching, the measurement of learning input has also become more diverse. Henrie et al. (2015) propose that online learning input can be quantified through indicators such as online click volume, interaction frequency, and feedback response.

At the level of teaching strategies, innovative teaching methods generally show a stronger effect of engagement promotion. For example, Domínguez et al. (2013) experimentally confirmed that

gamified learning is more effective than traditional teaching methods in terms of affective and cognitive engagement; Córdova-Esparza et al. (2024) found that project-based collaboration significantly enhances students' sense of active participation and team responsibility.

However, learning engagement is not a stable trait, but a “dynamic state variable” that is jointly influenced by the teaching context, motivational state, and ability foundation. Therefore, it is necessary to simultaneously examine whether the teaching method can stimulate motivation and whether students have the ability to cope in order to determine the true effect of teaching strategies on learning engagement.

Although the relevant variables have been studied extensively, there is currently a lack of research that systematically integrates the four within the same mechanism model. More importantly, most of the current research focuses on the context of Western higher education, and there is a lack of empirical exploration of the psychological mechanisms of college students in the context of digital transformation. Therefore, this study aims to fill the theoretical gap between “motivational mediation” and “literacy regulation” through quantitative analysis and model testing, in order to provide empirical support and path guidance for teaching innovation in colleges and universities.

Methodology

This study adopts a quantitative, explanatory, cross-sectional research design to explore the relationship between four core variables: teaching innovation, student motivation, digital literacy and learning engagement in the context of higher education. This study is based on positivist epistemology, which believes that psychological and behavioral phenomena can be revealed through objective and measurable data, so as to identify the causal relationships between variables and their internal mechanisms.

Theoretically, the research model is based on Self-Determination Theory (SDT) (Deci & Ryan, 1985, 2000) and Constructivist Learning Theory (Jonassen, 1999). Research hypothesis: Pedagogical innovation promotes students' learning engagement by stimulating their motivation, and this path is moderated by digital literacy.

A cross-sectional survey design is appropriate for this study, as the focus is on verifying theoretical hypotheses and revealing the mechanism between variables, rather than the evolution of dynamic processes. The research subjects are undergraduate students who have received courses on innovative teaching methods. A self-reported structured questionnaire was used to collect their subjective perceptions of teaching methods, learning motivation, digital competence and learning engagement. Although longitudinal studies can provide dynamic insights into the time dimension, the cross-sectional design has obvious advantages in this study in terms of resource constraints and operational feasibility.

In addition, this study is an explanatory study that not only focuses on describing students'

attitudes towards teaching methods or courses, but also focuses on the "how" and "why" of teaching methods affecting students' learning behaviors, so as to provide an empirical basis for the construction of a teaching mechanism model. This mechanism perspective coincides with the current theoretical needs of educational psychology research on mediation effects, regulatory mechanisms, and contextual adaptability.

To ensure the reliability, validity and cultural adaptability of the measurement tools, the scales used in this study were adapted and integrated based on established literature and international classic scales. All scales were scored using a Likert 5-point scale, ranging from "strongly disagree (1 point)" to "strongly agree (5 points)". The higher the score, the stronger the perception.

The "Innovative teaching methods" variable is measured based on the constructivist teaching principles and student-centered classroom characteristics, and integrates González-Gómez et al. (2016)'s "Perceived Flipped Classroom Scale", Bell (2010)'s project-based learning characteristics, and Kapp (2012)'s gamified learning elements, which ultimately form 14 items covering the dimensions of contextualized learning tasks, digital technology applications, collaborative interaction, and student autonomy. Sample items include: "My teacher encourages me to participate rather than just listen passively," "Multimedia and digital tools are used in class to enhance understanding," and "I can choose the topic of a project based on my interests."

The motivation measurement adopts the self-determination theory (SDT) framework, integrating the classic items from the Academic Motivation Scale (AMS) and the Self-Regulation Questionnaire–Academic (SRQ-A). There are a total of 9 items, covering intrinsic motivation (e.g., "I learn because I like the process of exploring knowledge") and extrinsic motivation (e.g., "I work hard to get rewards or avoid punishment"), which can effectively reflect the driving forces and types of regulation of student motivation.

The digital literacy scale is designed using the Digital Competence Framework for Students (DigComp) and the "digital self-efficacy" dimension proposed by Hong et al. (2014). It consists of 14 items and measures students' self-assessment abilities in information filtering, resource evaluation, online collaboration, content creation, and digital ethics. For example, "I can identify the credibility of online information," "I can use sharing tools to collaborate with others in learning," and "I can create multimedia content to facilitate learning."

The "learning engagement" variable is based on the three-dimensional model proposed by Fredricks et al. (2004), which includes behavioral engagement (e.g., attendance, completing assignments), affective engagement (e.g., interest in the course, sense of belonging), and cognitive engagement (e.g., using learning strategies, reflecting after class). There are a total of 15 questions, such as "I always complete tasks on time" and "I am willing to explore the content further after class."

Combining the theoretical model and literature review, this study proposes the following three core hypotheses:

H1: Innovative teaching methods have a significant positive impact on students' learning engagement.

H2: Motivation mediates the relationship between innovative teaching methods and learning engagement.

H3: Digital literacy moderates the impact of innovative teaching methods on learning engagement, and the positive effect is more significant for highly literate students.

To minimize sample bias and enhance the generalizability of the study, this study used stratified random sampling, with stratification based on variables such as grade, gender, major, and GPA. Samples were randomly selected within each stratum to ensure that students from different backgrounds were included in the analysis, effectively improving external validity.

The study was conducted in collaboration with university teachers, course leaders and the academic affairs office. All students interviewed were required to sign an electronic informed consent form through online or offline channels. The study strictly abides by university ethical review regulations to ensure that the data is anonymous, does not involve personal privacy, is not linked to grades, and that all data is used for academic research purposes only.

Data collection was divided into three stages:

Pre-test: 30 undergraduate students were invited to try filling in the preliminary version of the questionnaire to collect feedback to optimize the expression logic, completion time and cultural adaptability;

Formal distribution: The questionnaire was distributed online and offline via a QR code, with clear instructions on how to answer the questions and a promise of confidentiality.

Post-processing: Questionnaires with abnormal response times, highly consistent answers or high missing rates were eliminated.

The questionnaire has five sections: basic information, perception of innovative teaching methods, learning motivation, digital literacy and learning commitment. It is estimated to take 6–10 minutes to complete, and all questions are compulsory.

This study used a multi-stage statistical analysis process:

Descriptive statistics: analysis of mean, standard deviation, skewness, kurtosis, etc., to determine whether the distribution of variables is close to normal;

Correlation test: use Pearson correlation analysis to determine the preliminary relationship between variables and test the risk of multiple co-linearity;

Multiple regression analysis: test the direct effect of teaching methods on learning commitment (H1) based on the establishment of control variables;

Analysis of the mediating effect: Model 4 of the PROCESS macro is used to test the mediating effect of learning motivation (H2), and the Bootstrapping method is introduced to construct a confidence interval.

Analysis of the moderating effect: Model 1 is used to test the moderating effect of the "teaching method × digital literacy" interaction term on learning input (H3).

The entire modeling process will control background variables such as age, gender, and GPA, and report standardized regression coefficients, determination coefficients (R^2), and significance indicators.

Internal consistency was tested using Cronbach's α coefficient. All variable α values were above 0.85, indicating excellent scale reliability: teaching innovation: 0.852, student motivation: 0.864, digital literacy: 0.912, learning commitment: 0.927

Content validity: five domain experts were asked to assess whether the items conformed to the theoretical dimensions.

Structural validity: An exploratory factor analysis (EFA) was conducted, with a KMO = 0.931 and a significant Bartlett test. Four factors were extracted, which cumulatively explained 75.6% of the total variance. All item loads were >0.65, and the factor divisions were clear with no overlap.

This series of tests shows that the scale used in this study has good construct validity and discriminant validity, providing a scientific and reliable measurement basis for subsequent model analysis.

Results

This chapter systematically presents the results of the data analysis obtained in this study, with the aim of empirically verifying the research hypotheses proposed above. First, the sample structure is outlined through descriptive statistics, followed by t-tests and one-way analysis of variance (ANOVA) to explore group differences. Then, correlation analysis, regression model construction, and focus on testing mediation effects and moderating effects are carried out to reveal the mechanism path of how "innovative teaching methods", "student motivation" and "digital literacy" jointly affect "student learning engagement".

Descriptive statistical analysis

A total of 483 valid questionnaires were collected in this study, and the sample is well-diversified and representative in terms of gender, age, grade, major category, and average grade. In terms of gender structure, 51.1% were male and 48.9% were female, with an overall balanced gender distribution. In terms of age, 45.5% of the sample was under 18 years old, 30.2% were 19–21 years old, 22–24 years old was 18.6%, and 5.6% were over 25 years old, covering college students of all ages. The grade distribution shows that the highest proportion of students are freshmen (44.1%), followed by sophomores (30.8%), juniors (21.1%) and seniors (3.9%). In terms of major structure, education majors account for the highest proportion (41.8%), followed by science and engineering majors (22.6%), business administration majors (20.9%) and humanities and social sciences majors (14.7%). In terms of academic performance, those with a GPA of 3.0–3.9 accounted for the highest proportion (31.9%),

those with a score of 90 or above (or 4.0) accounted for 30.2%, those with a score of 70–79 accounted for 27.7%, and those with a score of 60–69 accounted for 10.1%. The overall sample structure is well-represented and structurally balanced, providing effective data support for subsequent statistical analysis.

Independent-sample t-test and one-way ANOVA analysis

The study used an independent-sample t-test to examine the impact of gender on the four core variables. The results showed that female students scored significantly higher than male students in the four variables of "perception of innovative teaching methods", "learning motivation", "digital literacy" and "learning input", and the differences were statistically significant ($p < 0.05$). Among these, the difference in student motivation was the most significant ($t = 2.895$, $p = 0.004$), indicating that gender may play an important role in the psychological mechanism of learning.

In terms of the age variable, the differences between the groups for all four variables reached a significant level ($p < 0.05$), especially in the dimension of students' learning input ($F = 3.476$, $p = 0.003$). This indicates that age has an important impact on students' perception of teaching, learning motivation and engagement. Older students may have higher self-regulation ability and goal-driven, showing higher cognitive engagement, while younger students are more active in emotional and behavioral engagement.

ANOVA with "grade" and "major category" as grouping variables showed that none of the four core variables showed statistically significant differences ($p > 0.05$) in these two background variable dimensions. This indicates that there are no systematic differences in perception of teaching, motivation levels and learning engagement between students of different grades or majors. Although "digital literacy" was close to significant ($p = 0.126$) in terms of major category, it still did not meet traditional statistical standards.

The grade point average (GPA) had a significant effect on students' learning engagement ($F = 4.481$, $p = 0.004$), indicating that students with better academic performance were more engaged in their studies. Other variables did not differ significantly between GPA groups, except for student motivation, which was nearly significant ($p = 0.096$), suggesting that high-achieving students may have a stronger tendency to be intrinsically motivated.

Analysis of correlation between variables

Table 1: Correlation Analysis

Variable	1	2	3	4
1. Innovative Teaching Methods	1	0.956	0.926	0.79
2. Student Motivation	0.956	1	0.883	0.798
3. Digital Literacy	0.926	0.883	1	0.852
4. Student Learning Engagement	0.79	0.798	0.852	1

In order to preliminarily explore the relationship between each core variable, this study used Pearson Correlation to conduct a bivariate correlation test on the four variables of "perception of innovative teaching methods", "student motivation", "digital literacy" and "student learning engagement". The sample size was N = 483, and the bilateral significance level was set at 0.01. The analysis results show that there is a significant positive correlation between each variable, and the correlation coefficients are at a high level.

Specifically, the correlation coefficient between "innovative teaching methods" and "student motivation" is $r = 0.956$, $p < 0.01$, indicating that students who perceive more innovative teaching methods tend to have stronger learning motivation. In addition, there is also a high positive correlation between "innovative teaching methods" and "digital literacy" ($r = 0.926$, $p < 0.01$), indicating that innovative teaching methods may be accompanied by an increase in the richness and frequency of use of the digital skills environment. The correlation between "innovative teaching methods" and "student learning engagement" is also significant ($r = 0.790$, $p < 0.01$), indicating a close link between instructional design and engagement in learning behaviors.

Meanwhile, the correlation coefficient between "student motivation" and "digital literacy" is $r = 0.883$, and the correlation coefficient with "learning engagement" is $r = 0.798$, both of which are significantly positive ($p < 0.01$), supporting the bridging role of motivation between technology adaptation and learning engagement. Finally, the correlation coefficient between "digital literacy" and "student learning engagement" also reached $r = 0.852$, $p < 0.01$, suggesting that technological skills may directly enhance students' engagement and confidence in learning tasks.

In summary, there is a strong positive correlation between all variables, with correlation coefficients exceeding 0.75 and all being significant at the 0.01 level. This result provides a solid statistical basis for the subsequent path analysis and the construction of a mediating and moderating model.

Results of regression analysis

In order to further test whether "innovative teaching methods" have a predictive effect on "student learning engagement," a univariate linear regression model was constructed, with "innovative teaching methods" as the independent variable and "student learning engagement" as the dependent variable. The results of the regression analysis are as follows.

First, judging from the Model Summary, the regression model's coefficient of determination $R^2 = 0.625$ indicates that "innovative teaching methods" can explain about 62.5% of the variance in students' learning input, and the adjusted $R^2 = 0.624$ shows that the model has strong explanatory power. The standard estimated error is 6.45, which is within an acceptable range.

Second, the results of the ANOVA analysis show that the regression model is significant, $F(1, 481) = 800.260$, $p < 0.001$, indicating that the overall model has good statistical significance, that is, the independent variable has a significant linear predictive effect on the dependent variable.

Table 2: Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.790[a]	.625	.624	6.44852

a. Predictors: (Constant), Innovative Teaching Methods

Table 3: ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	33277.518	1	33277.518	800.260	.000[b]
	Residual	20001.612	481	41.583		
	Total	53279.130	482			

a. Dependent Variable: Student Learning Engagement

b. Predictors: (Constant), Innovative Teaching Methods

Table 4: Coefficients[a]

Model		B	Std. Error	Beta	t	Sig.
1	(Constant)	8.732	1.687		5.175	.000
	Innovative Teaching Methods	.938	.033	.790	28.289	.000

a. Dependent Variable: Student Learning Engagement

In the regression coefficient analysis (Coefficients), the constant term is 8.732 ($p < 0.001$), while the unstandardized regression coefficient of “innovative teaching methods” is B = 0.938, the standard error is 0.033, the standardized regression coefficient (Beta) is 0.790, the t-value is 28.289, and the significance level $p < 0.001$, indicating that this predictor variable has a significant positive impact on students' learning commitment.

In summary, the results show that “innovative teaching methods” have a significant positive predictive effect on “student learning engagement,” that is, the more innovative teaching methods students perceive in the course, the higher their behavioral engagement, emotional engagement, and cognitive effort in learning activities. The model has strong explanatory power and clear statistical significance, providing a theoretical and empirical basis for further constructing a multiple path model.

Analysis of mediation effects

The Hayes PROCESS macro-Model 4 was used to test the mediating effect of “student motivation” between “pedagogical innovation” and “learning engagement”, with the following results:

The standardized path coefficient of pedagogical innovation on motivation is $\beta = 0.7978$;

the path coefficient of motivation on learning engagement is $\beta = 0.8968$;

The total effect is 0.6658, of which the direct effect is 0.063 ($p < 0.001$) and the indirect effect

is 0.6028 (Bootstrap confidence interval [0.5464, 0.6561], excluding 0, significant).

The mediating effect accounts for the majority of the total effect, indicating that "student motivation" is the key mechanism through which teaching strategies affect learning behavior. In other words, the reason why teaching methods are effective is largely because they stimulate students' motivation to learn, which in turn translates into specific learning behaviors.

Table 5: Intermediary Analysis

Path	Standardization coefficient (β)	p	Bootstrap 95% CI
Teaching Innovation → Student Motivation	0.7978	< 0.001	-
Motivation → Learning Engagement	0.8968	< 0.001	-
Teaching Innovation → Study Engagement (direct)	0.063	< 0.001	-
Indirect effect	0.6028	< 0.001	[0.5464, 0.6561]
Total effect	0.6658	< 0.001	-

Analysis of moderating effect

This study examined the role of moderating variables (Mo) in the relationship between independent variables (X) and the dependent variable (learning commitment) using hierarchical regression analysis. First, Model 1 only includes main effects, and the results show that the independent variables X (β=0.796, p<0.001), gender (β=0.065, p=0.020) and age (β=-0.112, p<0.001) have a significant predictive effect on learning commitment. When the moderating variable Mo was added to Model 2, the results changed significantly: the moderating variable showed a strong main effect (β=0.833, p<0.001), while the effect of the independent variable X became insignificant (β=0.024, p=0.699), indicating that the moderating variable may completely mediate or suppress the original effect of X. After the interaction term (X × Mo) was introduced in the final Model 3, the interaction effect did not reach a significant level (β = 0.029, p = 0.256), indicating that the moderating variable did not significantly change the strength or direction of the relationship between X and learning investment.

In terms of control variables, age always showed a stable negative predictive effect (β≈-0.11, p<0.001), indicating that older students were relatively less engaged in learning. The gender effect was only significant in the initial model, while the average grade also had no significant effect. It is worth noting that the constant term in all three models is highly significant (p<0.001), and the R^2 of Models 2 and 3 has significantly increased compared to Model 1, mainly due to the addition of moderating variables.

The comprehensive analysis shows that although digital literacy has an important independent explanatory power on students' learning engagement, it does not play the expected moderating role.

Table 6: Coefficients[a]

Model		B	Std. Error	Beta	t	Sig.
1	(Constant)	56.293	1.120		50.243	.000
	independent variable x	.945	.033	.796	28.976	.000
	Gender	1.358	.581	.065	2.338	.020
	Age	-1.279	.333	-.112	-3.841	.000
	Your average grade	-.100	.312	-.009	-.320	.749
2	(Constant)	55.684	.958		58.148	.000
	independent variable x	.029	.074	.024	.386	.699
	Gender	.778	.498	.037	1.562	.119
	Age	-1.263	.284	-.110	-4.442	.000
	Your average grade	-.075	.266	-.007	-.283	.777
	zt regulating variable x	.925	.069	.833	13.372	.000
3	(Constant)	55.441	.981		56.518	.000
	independent variable x	.019	.074	.016	.250	.803
	Gender	.829	.500	.039	1.659	.098
	Age	-1.271	.284	-.111	-4.469	.000
	Your average grade	-.078	.266	-.007	-.294	.769
	zt regulating variable x	.944	.071	.851	13.248	.000
	Interaction term X and Mo	.002	.002	.029	1.136	.256

a. Dependent Variable: Student Learning Engagement

Discussion

This study systematically explores the relationship mechanism between innovative teaching methods, student motivation, digital literacy and learning engagement based on empirical data. The results show that in the context of higher education, students' perception of teaching innovation not only has a direct impact on their learning engagement, but also plays a significant mediating effect through learning motivation. Although digital literacy does not show statistical significance in the mediation path, its main effect as an independent predictor factor is still highly explanatory. This chapter will systematically discuss the above findings from three levels: the testing and expansion of theoretical mechanisms, the differential performance of demographic variables, and the role and implications of digital literacy. The aim is to provide theoretical support and strategic suggestions for deepening educational theory and optimizing teaching practice.

First, the research results are highly consistent with the basic assumptions of Self-

Determination Theory (SDT). SDT believes that an individual's sustained behavior needs to be based on the full satisfaction of three basic psychological needs: autonomy, competence, and relatedness (Deci & Ryan, 1985). This study empirically found that the higher the students' perception of the "degree of teaching innovation" experienced in the classroom, the stronger their learning motivation, which further contributes to their learning investment in multiple dimensions of cognition, emotion, and behavior. This finding not only verifies the activating effect of a supportive teaching environment on motivation (Ryan & Deci, 2000), but also strengthens the applicability and explanatory power of SDT in the context of digital teaching transformation in universities.

Second, path analysis further revealed that the indirect effect in the chain "teaching method → learning motivation → learning input" was significantly greater than the direct effect, indicating that learning motivation played a central bridging role in the entire path. This structural mechanism also echoes the Game-based Learning Model proposed by Garris, Ahlers and Driskell (2002), which states that the improvement of interactivity, challenge and feedback mechanisms in the teaching context will stimulate the learner's intrinsic motivation, which will ultimately be translated into the persistence and initiative of learning behavior.

In addition, the path model of this study is also highly consistent with the core ideas of constructivist learning theory. Jonassen (1999) pointed out that learning is an active construction process with problem solving, reflection and social collaboration at its core, rather than the linear acceptance of knowledge. Innovative teaching methods, such as flipped classrooms, project-based learning and gamification, are based on this, emphasizing students' initiative in learning, contextual experience and multiple feedback, so as to effectively activate their learning momentum and enhance their level of investment. This study empirically expands the above theory using structural modeling, providing a mechanism to optimize instructional design towards deeper interaction and task-driven learning.

At the level of individual differences, this study identified two variables, "gender" and "age," as having a significant impact on learning motivation and engagement levels. Specifically, female students scored significantly higher than males on the three dimensions of "perceived instructional innovation," "learning motivation," and "learning engagement." This result is consistent with the view put forward by Voyer and Voyer (2014) in their large-scale meta-analysis, that is, women generally exhibit higher academic motivation, stronger self-discipline, and more sustained engagement. Related studies have also pointed out that women are more likely to seek teacher feedback, participate in extracurricular projects, and pay attention to process-oriented achievements in learning activities (Duckworth & Seligman, 2006). This suggests that universities should consider the influence mechanism of gender factors when designing teaching strategies, and develop more gender-adapted teaching methods, especially in the digital teaching environment, to improve the motivation level of male students through differentiated support.

In terms of the age variable, the study found that older students scored higher on the two dimensions of learning motivation and learning engagement, which may be due to their clearer career goals, more mature time management skills, and stronger sense of goal orientation. According to the Goal Setting Theory proposed by Locke and Latham (2002), individuals' goal clarity, self-regulation, and long-term planning skills will significantly increase with age, which in turn will lead to greater initiative and internal motivation in the learning process.

On the other hand, students' academic performance (GPA) also showed significant differences in the dimension of learning input, indicating that students with better academic performance showed higher levels of input in multiple aspects such as behavior, emotion and cognition. This may indicate that high-achieving students often have stronger information literacy and digital learning skills, and are better able to adapt to the task complexity and learning freedom brought about by teaching innovation.

In contrast, the grade level and type of major of the students did not show statistically significant differences, suggesting that learning behavior is more driven by individual psychological structure and self-efficacy than by the learning stage or subject attributes. This finding provides insights for universities to carry out general education curriculum reform and interdisciplinary teaching: the focus of teaching innovation should be more on activating and strategically supporting individual motivation mechanisms, rather than simply classifying courses based on majors or grades.

Although this study was unable to statistically confirm the moderating effect of “digital literacy” in the path of “innovative teaching methods → learning engagement”, its significance as an independent predictor still indicates its important underlying influence on learning behavior. In other words, digital literacy in this study is more likely to act as a prerequisite variable for “learning empowerment” rather than an amplifier or buffer for the effect of teaching strategies. This conclusion is highly consistent with the conceptualization of the European digital literacy framework proposed by Redecker (2017), which argues that digital literacy is not only the ability to operate tools, but also includes higher-order comprehensive abilities such as information evaluation, platform adaptation, strategy creation, and cross-platform collaboration.

Furthermore, the digital literacy measurement tool used in this study focuses mainly on basic operation and platform proficiency dimensions, which may not effectively capture students' abilities in terms of strategy, criticality, or innovation, resulting in its insignificant performance in the moderation path. Therefore, future research may consider introducing more discriminative dimension constructs into the scale design, such as “critical information identification”, “cross-platform migration ability”, “online collaboration efficiency”, etc., in order to more finely reveal the regulatory mechanism of digital literacy on adaptability to the teaching environment.

In addition, in view of the significant main effect of digital literacy, this study suggests that universities should simultaneously build a path for students to develop digital capabilities while promoting teaching innovation, including providing training in digital tools, constructing an online

learning support system, and offering thematic courses on information literacy, so that students can have the basic ability to cope with multiple teaching scenarios.

Conclusion

This section aims to systematically sort out and theoretically integrate the results of various statistical analyses. Through the comprehensive use of methods such as descriptive statistics, group difference tests (including independent sample t-tests and one-way ANOVA), inter-variable correlation analysis, regression prediction modeling, and tests of mediation and moderation effects, the study attempts to comprehensively reveal whether college students' perception of innovative teaching methods can significantly predict their learning engagement, and further explore the mediating mechanism of learning motivation and the moderating potential of digital literacy.

First, results from the independent sample t-test indicate statistically significant gender differences across all four core constructs: perceived innovative teaching methods, student motivation, digital literacy, and learning engagement. Female students scored significantly higher than their male counterparts in all dimensions ($p < .05$). This finding suggests that female students may be more adaptive to modern pedagogical environments and more inclined to exhibit proactive learning behaviors. The result aligns with existing literature showing that female students often demonstrate higher academic motivation, self-regulation, and consistent participation in learning activities.

Second, age-based differences were revealed through one-way ANOVA. Significant between-group differences were found across all four variables, with older students scoring notably higher in learning motivation and engagement. This trend is consistent with developmental psychology perspectives, particularly the positive association between learner maturity and motivation (Zimmerman, 2000). Older students often have clearer academic and career goals, more refined self-regulation skills, and a stronger internal drive, which collectively contribute to higher levels of cognitive and behavioral engagement.

In terms of academic achievement (GPA), significant group differences were observed only in the domain of learning engagement ($F = 4.481$, $p = 0.004$), while differences in the other three variables were not statistically significant. This result implies that students with higher academic performance are more likely to engage actively in their learning, possibly due to enhanced self-discipline, goal-setting ability, and time management skills.

Correlation analysis further confirmed significant and strong positive relationships among the four key variables. All correlation coefficients exceeded 0.75, indicating strong associations. Particularly, the correlation between perceived innovative teaching methods and student motivation was the strongest ($r = 0.956$, $p < .01$), suggesting that well-designed, innovative instructional approaches can serve as powerful external stimuli to activate students' intrinsic learning drives.

The most critical finding emerged from the mediation model analysis. Results indicated that

student motivation significantly mediates the relationship between innovative teaching methods and learning engagement. The indirect effect (0.6028) substantially outweighed the direct effect (0.063), and bootstrapped confidence intervals confirmed the statistical significance of this mediation effect (CI [0.5464, 0.6561], $p < .001$). These results provide empirical support for the core assumption of Self-Determination Theory (Deci & Ryan, 2000), which posits that autonomy-supportive learning environments foster intrinsic motivation, thereby enhancing sustained and deep engagement in learning tasks.

In contrast, the moderation analysis revealed no statistically significant interaction between digital literacy and innovative teaching methods in predicting learning engagement ($\beta = 0.029$, $p > .05$), although digital literacy itself emerged as a strong and significant predictor of engagement ($\beta = 0.833$, $p < .001$). This suggests that while digital literacy plays an essential enabling role in shaping students' learning behavior, its moderating effect—specifically, its capacity to strengthen or weaken the relationship between pedagogy and engagement—was not substantiated within this study's sample. One possible explanation lies in the scope of the digital literacy scale employed, which focused primarily on operational and familiarity aspects, potentially overlooking higher-order dimensions such as critical evaluation, strategic use, and creative digital production.

In summary, the empirical data lend robust support to the proposed theoretical model, confirming that innovative teaching positively impacts student learning engagement primarily through the mediating mechanism of motivation. Although digital literacy did not function as a significant moderator, its strong main effect reinforces its foundational role in academic participation. These findings offer important implications for both pedagogical theory and instructional practice, emphasizing the need for teaching approaches that actively cultivate student motivation while simultaneously supporting digital competency development.

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