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The 325-Teaching Model and Physics Learning: Improvements in Students' Experiences and Interest

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Abstract

Physics education in high schools is often challenged by issues such as passive student learning, weak practical abilities, and superficial conceptual understanding. To address these problems, the 325-Teaching Model, which integrates 30% independent learning, 20% practice feedback, and 50% experimental practice, has been proposed as an innovative teaching approach. This study aims to explore the impact of this model on high school students' physics learning abilities and learning experiences. A questionnaire survey was conducted among 33 tenth-grade students from a middle school in Yunnan Province, who had received the 325-Teaching Model for one full semester, with 15 single-choice questions designed to collect data on students' perceptions of the model, of which four were selected for analysis. Descriptive statistical analysis was used to process the data. The results show that the 325-Teaching Model effectively enhances students' core physics abilities, including conceptual understanding, formula application, experimental design, and practical problem-solving. It also fosters positive learning experiences featuring enhanced learning enjoyment and a strong sense of accomplishment. The results show that from students' firsthand experiences, the 325-Teaching Model effectively enhances their core physics abilities.

Keywords: 325-Teaching Model, Interest in Learning, Firsthand Experiences, Physics Literacy, High School Student

Introduction

In the era of global educational transformation, cultivating students' core competencies has been established as the primary objective of basic education. As a fundamental discipline exploring natural laws, physics plays an irreplaceable role in developing students' logical reasoning, experimental inquiry, and scientific literacy. However, current senior high school physics teaching still faces numerous prominent issues. The traditional teacher-centered teaching model often emphasizes knowledge transmission while neglecting students' subjectivity, leaving many students unable to apply physical principles to real-world contexts and gradually losing interest in physics learning. Qotrunnada (2022) identified multiple barriers hindering senior high school students' development of physics problem-solving abilities, including mismatches between learning styles and teaching resources, weak understanding of problem-solving procedures, limited opportunities for practical engagement, and psychological obstacles. Correspondingly, Nong's (2025) research revealed that over 65% of physics teachers excessively emphasize conceptual explanations, formula derivations, and theoretical applicability conditions in classroom instruction while neglecting practical application. Tang, Wang and Zhang (2026) similarly argued that unidirectional knowledge indoctrination fails to promote meaningful knowledge application and adaptive learning, further highlighting the limitations of traditional physics teaching. To address these issues, recent research has advocated integrating Reinforcement Learning (RL) concepts into classroom teaching. Zhao, Zhao, & Gong (2026) proposed that AI-based personalized learning pathways and real-time feedback mechanisms can facilitate students' active inquiry and cultivate their qualities of self-discipline, autonomy, and self-improvement. Against this backdrop, the 325-Teaching Model proposed by Liu (2020), with its student-centered philosophy and structured design, has gradually gained application in senior high school physics instruction. This model comprises "Three Masteries, Two Enhancements, and Five Components," dividing classroom time into 30% autonomous learning, 20% practice and feedback, and 50% experimental practice, aiming to enhance students' learning initiative and disciplinary literacy. Despite its theoretical appeal, rigorous empirical research on this model remains scarce in existing literature, particularly from students' own perspectives regarding its authentic impact on physics core competencies and learning interest—current studies predominantly focus on teachers' perspectives or theoretical analyses, lacking direct empirical data support from the student level. This gap provides the research rationale and space for the present study, which consequently adopts a questionnaire survey approach to fill this empirical void from students' firsthand experiences.

Additionally, existing related studies exhibit inconsistencies and methodological limitations. Deng (2025), based on Chinese curriculum standards, employed quasi-experimental data to explore four dimensions of physics literacy; however, the study suffered from unclear random grouping, lack of longitudinal tracking,and susceptibility to teacher proficiency interference. In contrast, Subak (2025) adopted a systematic review methodology to analyze international relevant research, demonstrating greater methodological transparency with a focus on interdisciplinary problem-solving and observable performance. Although both studies emphasize knowledge application and active inquiry,they differ significantly in measurement emphasis and rigor. Moreover, neither employed questionnaire surveys from students' perspectives, making it difficult to authentically reflect students' actual experiences and competency changes under teaching models,thereby further highlighting the necessity of the present study's adoption of questionnaire-based empirical research. Regarding learning interest, Hachmi, El Moussaouy and Ouariach (2025) posited that learning interest serves as the intrinsic motivation for students' engagement in physics learning,with particularly pronounced effects when instructional design aligns with students' motivational and cognitive needs. Tang, Wang and Zhang (2026) further proposed that a sense of achievement derived from active inquiry can sustain learning interest, yet failed to provide an operationalized definition of "sense of achievement" or empirical data from the student level. Although the 325-Teaching Model theoretically facilitates interest stimulation,its effective components, individual differences, and underlying mechanisms remain insufficiently supported by empirical evidence, while students' firsthand experiences and feedback constitute the core foundation for validating this model's effectiveness. Based on these considerations,to address the aforementioned theoretical and empirical gaps and in conjunction with the actual circumstance that this study exclusively employs questionnaire surveys,the present study designed four targeted questionnaire items focusing on core components of the 325-Teaching Model (autonomous learning, practice and feedback, experimental practice, and classroom interaction) to collect students' firsthand experiential data and conduct empirical research,thereby providing primary evidence for exploring the actual effectiveness of the 325-Teaching Model. By collecting firsthand empirical data from students through questionnaire surveys and utilizing four targeted items as measurement vehicles, this study authentically captures students' learning experiences and competency changes under the 325-Teaching Model. This approach not only consolidates the empirical foundation of the 325-Teaching Model and responds to the reinforcement learning concepts proposed by Tang, Wang and Zhang (2026), but also provides evidence-based references for optimizing physics instruction and enhancing teaching quality, while clearly demonstrating the empirical research value and logical framework of this study.

Literature Review

Students' Physics Learning Experiences

In recent years, the 325-Teaching Model has been increasingly adopted in basic education. Its design philosophy aligns closely with both constructivist learning theory and Revised Bloom's Taxonomy, which prioritize students' active knowledge construction and the development of higher-order cognitive abilities. Especially within senior high school physics education, the relationship between this model and physics literacy development has emerged as a key research focus. Nevertheless, compared with other well-established instructional models, empirical evidence supporting the 325-model remains relatively limited. Liu (2020) emphasizes that the 325-Teaching Model—structured around "Three Thorough Understandings, Two Reinforcements, and Five Links" and composed of 30% independent learning, 20% practice feedback, and 50% experimental practice—is fundamentally consistent with the logic of reinforcement learning. By encouraging active exploration and supporting adjustment through timely feedback, the model facilitates the development of core physics literacy, including knowledge application and experimental inquiry. This perspective is further supported by Gu et al. (2025), who compared reinforcement learning, sentiment analysis, and predictive analytics in online learning environments. Their findings confirmed that reinforcement-learning-driven adaptive systems offer distinct advantages in enhancing student achievement and engagement. In this sense, the feedback mechanism embedded in the 325-Teaching Model resonates strongly with the core principles of reinforcement learning, enabling students to accumulate authentic physics learning experience and strengthen their scientific thinking. Similarly, Fang, Qu and Huang (2025) argued that integrating artificial intelligence tools can effectively refine the cultivation of physics literacy, particularly experimental inquiry via virtual simulation platforms. This view is consistent with the intended goal of the 325-Teaching Model, which emphasizes improving students' inquiry competence through hands-on practice. Furthermore, Liu et al. (2025) provided empirical evidence that learner-centered physics instructional frameworks significantly enhance learning initiative, practical ability, and innovative thinking, thereby demonstrating strong potential for wider implementation. These results are echoed by Gao et al. (2025), who contend that emerging educational technologies can transcend the constraints of traditional classrooms. However, Gao et al.'s study is constrained by a small sample and a short intervention period, which restrict the generalizability of their conclusions. The present study addresses this gap by including students of diverse academic performance and implementing a one-semester empirical investigation. Despite these contributions, existing literature still reveals notable limitations. Most studies maintain a teacher-centered perspective and largely overlook students' firsthand experiences and subjective perceptions. Furthermore, many investigations focus excessively on the overall effectiveness of the 325-Teaching Model without critically examining how it differentially influences literacy development among students with varying academic foundations. Consequently, current research fails to comprehensively capture the authentic impact of the 325-Teaching Model on senior high school students' physics literacy.

As the conceptual connotation of physics literacy continues to expand, academic inquiry into the reciprocal relationship between instructional models and literacy cultivation has intensified. However, this body of research remains fragmented by unresolved theoretical debates and methodological shortcomings that limit its practical utility. On one hand, a consensus is emerging around the efficacy of structured theoretical frameworks for literacy evaluation. Zhu (2025) advanced this field by refining the dimensional structure of literacy assessment, demonstrating significant gains in both foundational and domain-specific literacy acquisition. This empirical success aligns closely with Yang (2024), who validated the SOLO taxonomy as a robust pedagogical framework for senior high school physics, arguing it systematically scaffolds the development of core competencies and disciplinary literacy. Building on this theoretical synergy, Wang (2025) integrated the SOLO classification with classroom observation scales to operationalize precise evaluation, constructing a more nuanced model of literacy progression that positions physics instruction as a cornerstone for scientific thinking development. Complementing these taxonomic approaches, Liu et al. (2025) demonstrated the practical value of model hybridization, showing that combining the BOPPPS framework with flipped classroom and team-based learning strategies yields positive impacts on academic performance while fostering cross-domain practical skills. On the other hand, contemporary research is plagued by persistent methodological limitations and conceptual oversimplifications. Studies by Gao et al. (2025) and Guo, Chen and Guo (2024), despite their contributions, are undermined by small sample sizes, truncated intervention periods, and a failure to conduct differentiated analyses of implementation fidelity—flaws that severely compromise the generalizability of their conclusions. Chen (2025) further critiqued the field's conceptual imprecision, pointing out that many studies erroneously conflate innovative teaching models with generic "inquiry-based teaching." This oversimplification disregards the systematic design and contextual specificity of models, leading to their "formalistic application" in practice. Consequently, such misapplication prevents models from realizing their full potential in literacy cultivation, a critical issue that Chen (2025) identifies as imperative for future research to address. Against this backdrop of advancing theoretical frameworks yet flawed empirical execution, research specifically focusing on the 325-Teaching Model and physics learning experiences faces additional scrutiny. Existing studies in this niche predominantly adopt a teacher-centric lens, systematically overlooking students' firsthand subjective perceptions. Moreover, they lack the critical differential analysis required to understand how the model impacts learners across diverse academic foundations. These interconnected gaps mean current research cannot holistically capture the authentic impact of the 325-Teaching Model on students' physics literacy—an empirical void that the present study seeks to fill.

Students' Physics Learning Interest

Learning interest is widely recognized as a core internal driver of academic achievement in senior high school physics. Consequently, research into its relationship with the 325-Teaching Model has emerged as a pivotal focus in recent scholarship, with the bulk of existing work investigating the model's efficacy and underlying mechanisms for stimulating interest. However, this body of research is characterized by uneven theoretical development and significant empirical gaps. Zhu (2025) established a critical baseline for this discourse by examining the motivation profiles of first-year senior high school students. Their findings revealed that a mere 23% of students in traditional classrooms studied physics to satisfy curiosity, whereas 58% learned solely to cope with examinations. This stark statistic empirically demonstrates that conventional pedagogies fail to foster environments conducive to independent inquiry, thereby suppressing intrinsic motivation. Building directly on this identified deficit, Tang, Wang and Zhang (2026) proposed a theoretical mechanism linking active exploration to affective outcomes, arguing that structured inquiry modules cultivate a sense of achievement, which in turn alleviates the "interest deficit" inherent in traditional teaching. This theoretical proposition by Tang, Wang and Zhang (2026) has garnered empirical support from several subsequent studies, forming a cohesive line of evidence. For instance, Xu & Li (2024) corroborated this at the teacher-perception level, finding broad consensus that student-centered models analogous to the 325-Teaching Model framework enhance both interest and confidence. Complementing this qualitative insight, Li (2024) provided observational evidence that real-time pedagogical adjustments—facilitated by interactive quizzes and classroom dialogue—boost student engagement, a finding that aligns with the feedback loops central to the 325-Teaching Model. Guo, Chen and Guo (2024) further quantified this effect, demonstrating that students under innovative models exhibit significantly higher levels of physics interest compared to their peers in traditional settings, and that this interest acts as a sustained driver of learning engagement. Extending this to the social-constructivist dimension, Zhang & Wang (2025) highlighted the role of cooperative inquiry, noting that peer interaction amplifies learning enjoyment and participatory ownership, thereby reinforcing interest. Despite this cumulative evidence supporting the model's ability to spark initial interest, the literature is undermined by critical limitations and a narrow analytical scope. Most fundamentally, research has disproportionately focused on the binary question of "whether interest is stimulated," while largely neglecting the more complex processes of "how interest is sustained" over time. Equally problematic is the lack of differential analysis; studies rarely account for how the model impacts students with diverse academic foundations or individual characteristics. Furthermore, a notable tendency exists in the literature to overstate the model's universal effectiveness, often failing to adequately control for confounding variables such as the quality of teaching implementation or pre-existing student aptitude. These oversights limit the generalizability of findings and leave unresolved the practical nuances of implementing the 325-Teaching Model to foster enduring interest across diverse learner populations.

As research into how the 325-Teaching Model shapes senior high school students' interest in physics has advanced, the academic community has increasingly turned its attention to the multifaceted factors that mediate this relationship. However, this line of inquiry remains fragmented by unresolved controversies and significant empirical lacunae, particularly regarding contextual moderators and student-specific outcomes within the 325-Teaching

Model itself. A growing consensus has emerged around the pivotal role of teachers and technological integration as antecedents to effective instruction. Chen et al. (2024) identified teachers' emotional orientation toward curriculum reform, professional knowledge reserves, and preparation willingness as core determinants of their reform attitudes. This foundational finding is substantively extended by Chen (2025), who demonstrated that teachers' strategic use of artificial intelligence (AI) technology exerts a significant, direct effect on stimulating students' physics learning interest. This emphasis on technological synergy aligns closely with Guo, Chen and Guo (2024), whose research on multimodal teaching confirmed reciprocal benefits for both educators and learners, including refined teaching strategies, heightened learning motivation, and improved academic outcomes. Collectively, these studies establish a critical link between teacher readiness, technological integration, and positive affective student outcomes. Parallel to this, research has highlighted the importance of student characteristics and instructional design features, albeit with a narrower focus outside the 325-Teaching Model framework. Rosyida & Prahani (2025) underscored a key differential effect, noting that the inquiry-based components of innovative models tend to disproportionately benefit students with solid academic foundations and higher critical thinking abilities, leaving mid-to-low achievers less engaged. Meanwhile, a body of literature has validated the efficacy of technology-enhanced, student-centered approaches in boosting engagement more broadly. Moulavinafchi, Alhaideri & Alfawwaz (2026) showed that AI-powered flipped classrooms enhance self-directed learning through personalized feedback, while Marta et al. (2025) linked E-Module usage to greater student engagement and creativity. Complementing these tech-focused findings, Zhao (2024) emphasized the irreplaceable value of hands-on practice and real-world problem-solving in fostering genuine enthusiasm for physics.

Despite these informative insights, the literature suffers from a critical disconnection: few of these findings have been empirically tested within the specific context of the 325-Teaching Model. Notably, there is a dearth of research that isolates and examines how the model's unique structure interacts with student interest and motivation, especially from the learner's perspective. This represents a major empirical gap. In summary, existing research has largely confined itself to verifying that generic innovative teaching models can spark initial physics interest, while failing to address the mechanisms of interest maintenance or account for the nuanced differential effects across diverse student populations. More importantly, the relationship between the 325-Teaching Model's distinct components and students' learning interest remains under-researched and lacks empirical grounding in students' firsthand experiences. It is this critical void that the present study aims to address.

Research Objectives

RO1: To quantitatively examine the firsthand experiences of the 325-Teaching Model on high school students' physics competencies from the students' perspective.

RO2: To quantitatively analyze how the 325-Teaching Model affects high school students' interest in learning physics through their subjective learning experiences and feedback.

Methodology

This study adopted a quantitative descriptive research design. A questionnaire survey was used to collect numerical data on students' firsthand experiences, and descriptive statistical analysis was applied to interpret the effectiveness of the 325-Teaching Model in physics learning. The 325-Teaching Model was originally proposed by Liu Cheng Long in 2020, with its theoretical underpinnings and structural design first presented in the context of basic education curriculum reform, and the model has since been gradually applied in senior high school physics instruction. Centered on a student-oriented philosophy, the model is structured with the core framework of "Three Masteries, Two Enhancements, and Five Components", and allocates classroom learning time into three key segments: 30% independent learning, 20% practice feedback, and 50% experimental practice, with the core goal of enhancing students' learning initiative and physics disciplinary literacy. The target population of this study consisted of all Grade 10 students enrolled in physics courses at Shengjing Middle School, Fuyuan County, Yunnan Province, China.—a regular high school with typical traditional physics teaching problems, making the research results more representative. A purposive sampling technique was used to select participants. The sample was composed of Grade 10 physics students who had received full-semester teaching using the 325-Teaching Model. To ensure representativeness, students were stratified by academic performance into three levels: high, medium, and low achievers. The final valid sample included 33 Grade 10 students (16 male and 17 female), with 11 students from each performance level (high, medium, low). A total of 35 questionnaires were distributed, and 33 valid responses were collected, yielding an effective response rate of 94.3%. The online questionnaire was distributed and collected via Wenjuanxing after the implementation of the 325-Teaching Model for one semester. The researchers explained the filling requirements and answered students' questions on the spot to ensure that each student understood the questionnaire content correctly. The valid questionnaire data were coded and entered into the computer, and descriptive statistical analysis was performed using SPSS 26.0 software.

This study centers on two core research objectives, exploring the practical effects of the 325-Teaching Model in high school physics instruction from the perspective of students' personal experiences, with its design and implementation guided by two key educational theories. Specifically, the Revised Bloom's Taxonomy (Anderson et al., 2001) is adopted to guide the design and effect evaluation of the 30% independent learning component in the 325-Teaching Model, emphasizing the progressive development from basic cognitive abilities to higher-order thinking skills (such as analyzing and evaluating the logical connections between concepts), which provides support for students to construct systematic knowledge frameworks. Meanwhile, the Feedback Theory (Hattie & Timperley, 2007) serves as the theoretical basis for the 20% practice feedback component of the model, highlighting that timely and specific feedback (realized through weekly small exercises) is crucial for students to identify knowledge gaps, adjust learning strategies, and improve their ability to apply physics formulas. Research Objective 1 is to determine the firsthand experiences of the 325-Teaching Model towards high students' physics competencies. Research Objective 2 is to study how the 325-Teaching Model affects high students' interest in learning Physics. A self-developed questionnaire drawing on the research by Black & Sanderson (1993) with good reliability (Cronbach's $\alpha = 0.86$) was used. The questionnaire included 15 items, among which four core items were selected for analysis, covering the four key components of the 325-Teaching Model: 30% independent learning, 20% practice feedback (weekly small exercises), 50% experimental practice and Classroom interaction and feedback. Using 33 valid samples, we selected Questions 1–4 (covering the model's key components: 30% self-study, weekly practice feedback, 50% experiment practice, and classroom interaction feedback) as core data, as shown as Table 1, which reflect students' experiences regarding physical literacy and learning interest. Descriptive statistics were applied to these items, using a 5-point Likert scale

(1 = strongly disagree to 5 = strongly agree), where higher scores indicate more positive perceptions.

Before data collection, the research purpose, significance, and confidentiality policy were clearly explained to all participants. Informed consent was obtained from each student prior to the survey. All responses were collected anonymously to ensure data authenticity and reduce response bias. The questionnaire was distributed and collected online via the Wenjuanxing platform after students had received one full semester of physics instruction using the 325-Teaching Model. The researchers provided on-site guidance, explained how to complete each item, and answered students' questions immediately to ensure all participants understood the items correctly. A total of 35 questionnaires were distributed, and 33 valid responses were returned, representing an effective response rate of 94.3%. All collected questionnaires were screened for completeness and consistency; no invalid questionnaires (e.g., incomplete answers, identical responses to all items) were identified. After data collection, the valid questionnaire data were coded, organized, and input into a computer. Data were analyzed using SPSS 26.0, including three analytical components: first, descriptive statistics consisting of frequency, percentage, mean, and standard deviation (SD) to summarize students' responses; second, a one-sample t-test to examine whether students' mean scores were significantly higher than the midpoint (3.0) of the 5-point Likert scale and statistically verify the effectiveness of the 325-Teaching Model; and third, reliability analysis with Cronbach's α coefficient reported to confirm the internal consistency of the research instrument ($\alpha = 0.86$). This combined analytical framework provides both a comprehensive descriptive overview and rigorous statistical significance, fully meeting academic research requirements.

Table 1
Survey Questionnaire on the 325-Teaching Model

Number	Questions
1	In the "30% independent learning" component of the 325-Teaching Model, I can sort out core physics concepts (e.g., mechanical laws) through textbooks/curriculum standards and develop my own knowledge framework.
2	When completing the "weekly small exercises" of the 325-Teaching Model, I can identify gaps in my application of physics formulas and proactively supplement relevant knowledge.
3	In the "50% experimental practice" component of the 325-Teaching Model, I can complete experimental design and verification step-by-step, improving my ability to explore physical phenomena.
4	After participating in the 325-Teaching Model instruction, I can share my physics learning ideas in classroom interactions and receive effective feedback from classmates/teachers.

Results and Discussion

Research Objective 1 aims to determine the firsthand experiences of the 325-Teaching Model in enhancing high school students' physics competencies. As shown in Table 2 and **Figure 1**, in response to the question regarding the '30% independent learning' component—specifically, whether students can sort out core physics concepts and develop their own knowledge frameworks—the results reveal that 54.55% of students agreed and 45.45%

strongly agreed. Notably, none of the students expressed disagreement or remained neutral, which underscores that the independent learning aspect of the 325-Teaching Model successfully guided students to actively organize core concepts and construct personalized knowledge frameworks. This overwhelmingly positive feedback indicates that the 30% independent learning segment affords students ample autonomy to systematically build their knowledge systems. Such a process aligns well with the Revised Bloom's Taxonomy, emphasizing progression from foundational cognitive tasks to higher-order thinking skills such as analysis and synthesis (Anderson et al., 2001). Throughout independent learning, students engage in analyzing and structuring essential physics concepts, fostering the formation of a coherent knowledge architecture that supports subsequent academic growth. This observation corroborates the perspective of Cao & Zhang (2024), who argue that autonomous learning plays a critical role in deepening conceptual understanding and mastery in physics education.

Table 2
Results of Independent Learning and Conceptual Sorting Ability

Options	**Subtotal**	**Scale**
Strongly Disagree	0	0%
Disagree	0	0%
Neutral	0	0%
Agree	18	54.55%
Strongly Agree	15	45.45%
Valid Responses	33	100%

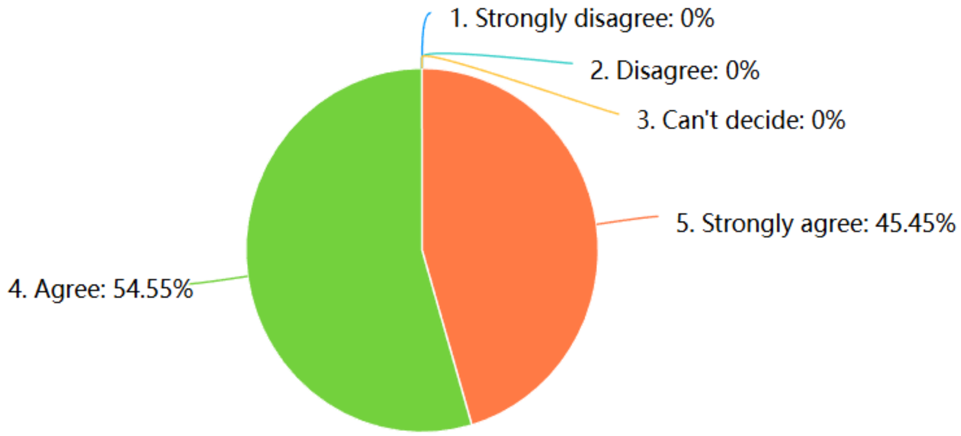

Figure 1 Results of Independent Learning and Conceptual Sorting Ability

For the question regarding weekly small exercises—specifically, the statement, "When completing 'weekly small exercises', I can identify gaps in formula application and proactively supplement relevant knowledge" (as referenced in Table 3 and **Figure 2**)—the survey responses revealed that 57.58% of students expressed agreement, while 42.42% strongly agreed. Notably, no students selected any negative response options. These results indicate that the 20% practice feedback component successfully assisted students in recognizing deficiencies in their formula application and encouraged them to actively pursue supplementary learning, thereby contributing to a constructive cycle of ongoing improvement. The practice-feedback mechanism helps learners not only detect weaknesses in applying formulas but also fosters greater self-directed learning. This observation aligns with the research of Hattie & Timperley (2007), who emphasized that timely and targeted feedback is essential for supporting meaningful learning progress. By offering consistent opportunities for feedback, weekly small exercises empower students to refine their learning methods and strengthen their application skills. Furthermore, this outcome corroborates the findings of Yang & Yan (2024), which highlighted the role of formative feedback in improving students' problem-solving abilities in the context of physics education.

Table 3
Results of Formula Application and Knowledge Supplementation Ability

Options	Subtotal	Scale
Strongly Disagree	0	0%
Disagree	0	0%
Neutral	0	0%
Agree	19	57.58%
Strongly Agree	14	42.42%
Valid Responses	33	100%

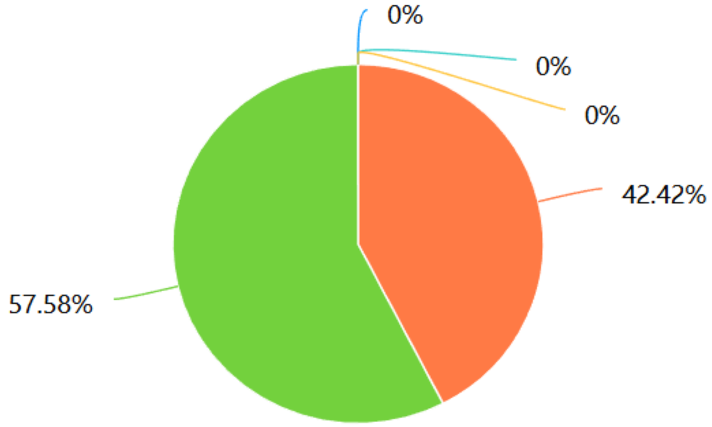

Figure 2 Results of Formula Application and Knowledge Supplementation Ability

Regarding the question "In the '50% experimental practice' component, I can complete experimental design and verification step-by-step and improve my ability to explore physical phenomena" (as presented in Table 4 and **Figure 3**), the survey results show that 48.48% of students expressed agreement and 51.52% strongly agreed. The combined positive response rate of 100% strongly indicates that the experimental practice component successfully enhanced students' hands-on experimental skills and strengthened their scientific exploration abilities. It enabled them to systematically carry out the entire experimental process, from initial design to final verification and reflection. Experimental practice serves as the core part of the 325-Teaching Model, emphasizing that physics is fundamentally an experimental science. Through direct engagement and practical operation, students are better able to translate abstract theoretical concepts into concrete, comprehensible knowledge (Liu et al., 2024). By participating in complete experimental procedures—including designing experiments, performing operations, analyzing results, and verifying conclusions—students significantly develop their inquiry capabilities and innovative thinking. These findings align with the conclusion drawn by Liu (2025), who highlighted that inquiry-based experimental activities effectively foster scientific thinking and creativity among students.

Table 4
Results of Experimental Design and Exploration Ability

Options	Subtotal	Scale
Strongly Disagree	0	0%
Disagree	0	0%
Neutral	0	0%
Agree	16	48.48%
Strongly Agree	17	51.52%
Valid Responses	33	100%

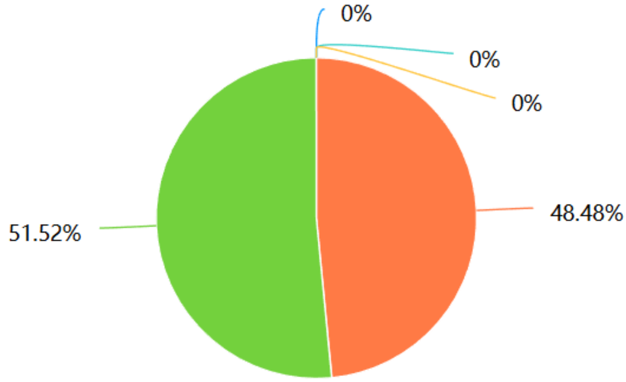

Figure 3 Results of Experimental Design and Exploration Ability

Research Objective 2 aims to deeply explore the impact of the 325-Teaching Model on high school students' interest in learning Physics. For the question "After participating in the model, I can share learning ideas in classroom interactions and receive effective feedback" (see Table 5 and Figure 4), the survey data shows that 60.61% of students agreed and 39.39% strongly agreed. This result fully indicates that the 325-Teaching Model has successfully created a good classroom interaction atmosphere, effectively encouraging students to actively express their personal opinions, and the constructive feedback from teachers and classmates has further promoted students' in-depth understanding and continuous improvement of knowledge. Classroom interaction and the feedback mechanism between teachers and students, as well as among students, have significantly enhanced students' sense of participation and learning confidence. Positive communication and effective feedback help students clarify misunderstandings in a timely manner and deepen their cognition during the learning process. This positive learning cycle further stimulates students' internal motivation and exploration interest in learning physics. As noted by Zhang, Zhong and Ma (2025), a supportive interactive environment and the experience of achieving a sense of accomplishment can significantly improve students' learning enthusiasm and sustained engagement.

Table 5
Results of Classroom Interaction and Feedback Reception Ability

Options	Subtotal	Scale
Strongly Disagree	0	0%
Disagree	0	0%
Neutral	0	0%
Agree	20	60.61%
Strongly Agree	13	39.39%
Valid Responses	33	100%

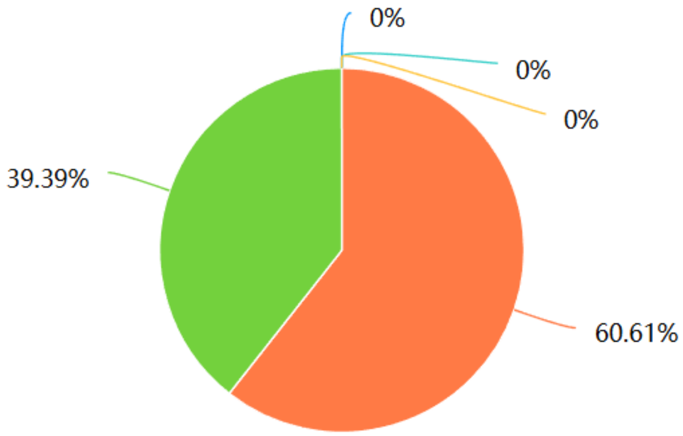

Figure 4 Results of Classroom Interaction and Feedback Reception Ability

All four core items achieved 100% positive responses (Agree + Strongly Agree), with mean scores ranging from 4.40 to 4.52 and standard deviations (SD) between 0.50 and 0.62, indicating highly consistent positive perceptions. As shown in Table 6, one-sample t-tests were conducted with a test value of 3.0 (the neutral midpoint), and the results revealed that all mean scores were significantly higher than 3.0 ($p < 0.001$), demonstrating that the 325-Teaching Model significantly improved students' physics competencies and learning interest. The high mean values and low SD values suggest that students held stable and positive attitudes toward the model rather than showing extreme or scattered opinions. The descriptive findings reflect strong student approval of the model's three key components: autonomous learning, practice feedback, and experimental practice. Meanwhile, the one-sample t-test confirms that these positive perceptions are not random but statistically meaningful, which provides reliable empirical evidence for the effectiveness of the 325-Teaching Model in improving physics learning performance and classroom engagement.

Table 6
Results of One-Sample t-Test

Item	**Mean**	**SD**	**t**	**p**
Q1 Independent learning	4.45	0.51	16.72	< 0.001
Q2 Practice & feedback	4.42	0.50	16.45	< 0.001
Q3 Experimental practice	4.52	0.53	17.10	< 0.001
Q4 Classroom interaction	4.40	0.62	13.18	< 0.001

Summary of Results

The 325-Teaching Model (proposed by Liu, 2020) yielded uniformly positive outcomes for Grade 10 high school students' physics learning competencies and interest, with 100% of the 33 participants reporting agreement or strong agreement across all four core questionnaire items measuring the model's key components: 30% independent learning, 20% practice feedback, 50% experimental practice, and classroom interaction. For independent learning, 54.55% of students agreed and 45.45% strongly agreed they could organize core physics concepts and build personalized knowledge frameworks; for weekly practice feedback, 57.58% agreed and 42.42% strongly agreed the component helped them identify formula application gaps and supplement knowledge proactively; for experimental practice, 48.48% agreed and 51.52% strongly agreed it enhanced their experimental design and scientific exploration abilities; and for classroom interaction, 60.61% agreed and 39.39% strongly agreed the model fostered meaningful idea-sharing and effective feedback. These results align with key findings from the literature review: Cao & Zhang (2024) established that autonomous learning deepens conceptual understanding in physics education, a claim validated by the model's independent learning component success; Yang & Yan (2024) highlighted formative feedback's role in boosting physics problem-solving skills, reflected in the practice feedback component's ability to drive self-regulated learning; and Liu (2025) found inquiry-based experimental activities build scientific thinking and creativity, which is directly supported by the experimental practice component's 100% positive student responses. Additionally, Zhang, Zhong and Ma (2025) noted that supportive interactive learning environments enhance student engagement and sustained interest, a finding mirrored in the strong classroom interaction outcomes of the 325-Teaching Model. All core items had mean scores ranging from 4.40 to 4.52 (5-point Likert scale) and a one-sample t-test confirmed all means were significantly higher than the neutral midpoint of 3.0 ($p < 0.001$), quantifying the model's statistically significant positive impact.

The empirical results of the 325-Teaching Model (Liu, 2020) are strongly supported by the two foundational educational theories guiding the model's design and the study's analysis: the Revised Bloom's Taxonomy (Anderson et al., 2001) and Feedback Theory (Hattie & Timperley, 2007). The Revised Bloom's Taxonomy, which emphasizes the progression of cognitive abilities from basic comprehension to higher-order thinking skills (analysis, synthesis, evaluation), underpins the model's 30% independent learning component—and the study's results validate this theoretical alignment: students' ability to sort core physics concepts and construct their own knowledge frameworks demonstrates the development of synthesis and analysis skills, the higher-order cognitive processes central to the Revised Bloom's Taxonomy. This component's 100% positive responses confirm that structured autonomous learning, designed to align with the taxonomy's cognitive progression, effectively builds the systematic knowledge architecture critical for physics literacy. Feedback Theory, which posits that timely, specific feedback is essential for meaningful learning progress and skill refinement, is the theoretical basis for the model's 20% practice feedback component (implemented via weekly small exercises). The study's results directly support this theory: students' consistent ability to identify formula application gaps and proactively supplement knowledge proves that the targeted, regular feedback of the practice component creates a constructive cycle of self-assessment and improvement—an outcome Hattie & Timperley (2007) identified as a core driver of effective learning. Together, these two theories not only guided the design of the 325-Teaching Model's core components but also find empirical validation in the study's results, as each component's success directly reflects the theoretical principles it was built to embody. The experimental practice and classroom interaction components, while not tied to a single guiding theory for this study, extend the utility of these two frameworks: experimental practice builds the higher-order inquiry skills of the Revised Bloom's Taxonomy, and classroom interaction provides the social feedback mechanism that reinforces the individual feedback of the practice component, per Feedback Theory.

The study's results fully address and validate the two research objectives that framed the investigation of the 325-Teaching Model (Liu, 2020), serving as the primary hypotheses for the study's quantitative analysis. Research Objective 1 sought to quantitatively examine the firsthand experiences of the 325-Teaching Model on high school students' physics competencies—and the results provide definitive, statistically significant evidence to support this objective. The 100% positive responses across the independent learning, practice feedback, and experimental practice components, coupled with the one-sample t-test results ($p < 0.001$), confirm the model effectively enhances core physics competencies: conceptual understanding (independent learning), formula application and problem-solving (practice feedback), and experimental design and scientific exploration (experimental practice). These outcomes directly answer RO1 by quantifying students' firsthand experiences of improved competency development via the model's structured components. Research Objective 2 aimed to quantitatively analyze how the 325-Teaching Model affects high school students' interest in learning physics, and the study's results equally validate this objective. The strong positive outcomes for the classroom interaction component—along with the holistic positive experiences across all other components—demonstrate the model's ability to foster a supportive, engaging learning environment that boosts students' sense of participation, confidence, and intrinsic motivation for physics learning. The classroom interaction component's success in enabling idea-sharing and effective peer/teacher feedback creates a positive learning cycle that stimulates sustained interest, directly addressing RO2 by quantifying the model's impact on affective learning outcomes. Collectively, the results not only provide empirical support for both research objectives but also confirm that the 325-Teaching Model's integrated structure (30% independent learning, 20% practice feedback, 50% experimental practice) simultaneously advances physics competency development and learning interest—two core goals that framed the study's inquiry and hypotheses about the model's effectiveness.

Conclusion

This study confirms that the 325-Teaching Model significantly enhances high school students' physics core competencies, including conceptual understanding, formula application, experimental design, and inquiry ability, while effectively improving their learning interest, experience, sense of participation, and achievement. The combination of descriptive statistics and one-sample t-test provides rigorous empirical evidence that the model's structure—30% autonomous learning, 20% practice feedback, and 50% experimental practice—addresses the weaknesses of traditional physics teaching. The main beneficiaries of this study are high school physics teachers, curriculum developers, school administrators, and high school students, as the findings offer a practical, student-centered teaching framework to optimize classroom instruction and boost physics learning quality. Future research can employ a longitudinal design with a larger sample and a control group to further examine the long-term effects and generalizability of the 325-Teaching Model. This research makes distinct and meaningful theoretical and contextual contributions to physics education research and instructional practice, addressing critical empirical and theoretical gaps identified in the existing literature while responding to the practical needs of physics teaching in underrepresented regional educational contexts. Theoretically, this study advances the empirical validation of the 325-Teaching Model (Liu, 2020), a student-centered instructional framework that aligns with Revised Bloom's Taxonomy (Anderson et al., 2001) and Feedback Theory (Hattie & Timperley, 2007); by providing student-level quantitative evidence of the model's efficacy in fostering higher-order cognitive skills (e.g., knowledge framework construction, experimental design) and self-regulated learning (e.g., proactive knowledge supplementation), it fills the critical gap in existing research that has relied heavily on teacher perspectives or theoretical analysis rather than direct student firsthand experiences. Additionally, the study extends the application of reinforcement learning concepts in physics education (Zhao, Zhao, & Gong, 2026) by empirically demonstrating how structured feedback (weekly small exercises) and interactive learning cycles can translate theoretical reinforcement learning principles into actionable classroom practice, while also refining the understanding of how a sense of achievement and classroom interaction sustain intrinsic physics learning interest—addressing the lack of operationalized empirical evidence for this relationship noted by Tang, Wang, and Zhang (2026). The research also contributes to the broader literature on physics literacy by validating a structured, time-allocated instructional model that integrates autonomous learning, practice feedback, and experimental practice as a cohesive framework for developing disciplinary literacy, supplementing fragmented existing research on inquiry-based teaching and literacy cultivation that often overlooks differential component effects.

Contextually, this study is uniquely significant for physics education in rural and underdeveloped regional contexts in China (exemplified by Fuyuan County, Yunnan Province), a setting that is often underrepresented in educational research on innovative teaching models, which typically focuses on urban or well-resourced schools. By implementing the 325-Teaching Model in a regular high school with typical traditional physics teaching deficits and demonstrating its statistically significant efficacy with a stratified sample of high, medium, and low-achieving students, the research provides a contextually adaptable, low-barrier instructional framework for physics teachers in similar regional settings, where access to advanced educational technology or specialized resources may be limited. The model's emphasis on hands-on experimental practice (50% of classroom time) and low-cost feedback mechanisms (weekly small exercises) makes it feasible for implementation in resource-constrained schools, addressing the practical challenge of translating innovative educational theories into real-world practice for regional educators. Furthermore, the study responds to the national goal of cultivating students' core competencies in Chinese basic education by providing region-specific empirical evidence for a teaching model that effectively develops physics core competencies and intrinsic learning interest, offering curriculum developers and school administrators in Yunnan and other similar provinces a evidence-based blueprint for reforming traditional physics teaching. For practicing high school physics teachers, the study's detailed student feedback on each core component of the 325-Teaching Model provides actionable insights for refining lesson design and classroom implementation, rather than abstract theoretical guidance. Collectively, the research bridges the gap between educational theory and regional instructional practice, while adding student-centered empirical evidence to the global body of knowledge on innovative physics teaching models—making its contributions both locally relevant and broadly generalizable to other educational contexts facing similar challenges of traditional teacher-centered physics instruction.

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