International Journal of Evaluation and Research in Education (IJERE)
Vol. 15, No. 4, August 2026, pp. 2904~2918
ISSN: 2252-8822, DOI: 10.11591/ijere.v15i4.39090

A pathway model for physics teachers' pedagogical philosophy core competency development

Ze He[1], Lumeng Chao[2], Xiaofei Xue[3]
[1]School of Physics and Electronic Information Engineering, Jining Normal University, Ulanqab, China
[2]Ulanqab Mongolian Middle School, Ulanqab, China
[3]Office of Party and Government Affairs, Jining Normal University, Ulanqab, China

Article Info

Article history:

Received Feb 12, 2026
Revised Jul 6, 2026
Accepted Jul 14, 2026

Keywords:

Core competencies
Physics teaching philosophy
Professional growth
Teacher development
Teaching competence

ABSTRACT

The implementation of the National Education Development Plan (2024–2035) has propelled Chinese physics education from traditional knowledge transmission toward a core competency-oriented teaching model. This transformation need to impose new demands on educationally underserved central and western regions, how teachers adapt to this shift presents an urgent challenge. This study aims to systematically analyze secondary physics teachers' cognitive levels regarding core competencies, examine the consistency between teaching philosophies, practices, and focus on how individual teacher characteristics and external support conditions influence professional development. The sample comprised 320 secondary physics teachers from Ulanqab City, selected via stratified random sampling to ensure representativeness, with 48 teachers participated in a quasi-experimental intervention study. Findings indicate that teachers' overall core literacy cognition levels were moderately high ($M=3.86$, $SD=0.42$), though 35.0% reached high levels. Significant differences existed across teaching experience and professional titles ($p<0.05$). In teaching practice, alignment between pedagogical beliefs and behaviors remained low overall ($r=0.42$), with traditional knowledge transmission still dominant. Teachers' personal characteristics, school support, and peer collaboration played crucial roles in conceptual transformation, collectively explaining 68.4% of the variance. Through a three-dimensional development model built on theoretical learning, reflective practice, and collaborative exchange, teachers demonstrated significant improvements in instructional design, classroom organization, and reflective refinement (Cohen's $d=0.58$–0.91). This study provides empirical support for teacher professional development mechanisms while offering practical references for advancing regional educational equity and high-quality physics instruction.

Corresponding Author:

Xiaofei Xue
Office of Party and Government Affairs, Jining Normal University
012000 Ulanqab, Inner Mongolia, China
Email: jnnuphysics@163.com

1. INTRODUCTION

The implementation of China's Education Powerhouse Development Plan (2024–2035) has elevated teacher professional development and subject-specific instructional reform to central priorities in the country's educational strategy. As a core subject in secondary education, physics is undergoing profound transformations in its teaching models and educational objectives. Historically, physics classrooms have centered on knowledge transmission and problem-solving drills, leaving students stuck at the level of memorizing concepts and performing mechanical calculations. This approach has failed to systematically cultivate scientific thinking, inquiry skills, and interdisciplinary transfer abilities. Such practices fall significantly short of the educational demands driven by core literacy frameworks, compelling teachers to shift their mindset from being "knowledge disseminators" to "facilitators of literacy development".

International research indicates that this conceptual shift in teachers' roles is not only central to educational reform but also pivotal to classroom effectiveness. Liu and Sun [1] found that teaching methods grounded in scaffolding and guided discovery significantly enhance students' analytical and reasoning abilities, whereas traditional knowledge-transmission approaches struggle to foster higher-order thinking. Further research by Neumann and Nordine [2] demonstrated that teachers can effectively enhance classroom quality through action research and sustained dialogue within learning communities. This process not only improves student learning outcomes but also strengthens teachers' professional competence. These findings indicate that conceptual transformation is not an isolated individual act but an integrated process closely linked to teacher collaboration, school support, and institutional environments.

However, updated beliefs do not automatically translate into improved practices. Fischer and Kauertz [3] reveal that teachers often face constraints from self-efficacy when confronting instructional innovations; insufficient psychological beliefs and technical capabilities diminish the likelihood of implementing new ideas. Koswojo *et al.* [4], examining science, technology, engineering, and mathematics (STEAM) education, emphasize that interdisciplinary training expands teachers' pedagogical content knowledge (PCK), facilitating multidimensional knowledge integration in classrooms. This indicates that genuinely advancing physics classroom reform requires simultaneous attention to teachers' cognitive, affective, and behavioral dimensions, thereby enhancing their capacity to translate concepts into teaching practices.

Reviewing relevant domestic and international research reveals persistent gaps in teacher professional development. Mulhayatiah *et al.* [5], through an 18-year longitudinal study, indicate that short-term training often fails to yield sustained improvement, emphasizing that teacher growth necessitates long-term support and systematic planning. This issue is particularly pronounced in China's central and western regions. Taking Ulanqab City in Inner Mongolia as an example, its remote location and limited educational resources create widespread difficulties for teachers in accessing high-quality training and cross-school collaboration opportunities. Becker *et al.* [6] explicitly state that geographic and socioeconomic factors profoundly impact the accessibility and quality of teacher professional development, constituting a key reason for persistent urban-rural educational disparities. This demonstrates that transforming pedagogical beliefs and enhancing teaching competencies are not merely theoretical issues in education but also practical challenges for achieving balanced regional educational development.

To address these issues, this study adopts a mixed-methods research approach, as shown in Figure 1. Quantitative research employs surveys to comprehensively collect data on teachers' understanding of core competencies, pedagogical philosophies, and instructional capabilities. Structural equation modeling (SEM) is then used to analyze the causal relationships between conceptual transformation and competency enhancement. Qualitative research utilizes interviews and classroom observations to deeply uncover the obstacles and breakthrough points teachers encounter in practice, thereby enriching our understanding of the underlying mechanisms behind the data. This combined quantitative-qualitative research design ensures comprehensive and credible conclusions while providing more interpretive evidence to support teacher development.

Building on this foundation, the value of this study lies not only in validating the effectiveness of teacher concept transformation under a core competencies framework but also in constructing a competency enhancement pathway adaptable to diverse educational contexts. Compared to previous studies, this research offers unique contributions in three aspects. First, it reveals the causal chain linking teacher conceptual transformation to instructional competency enhancement through an integrated model, overcoming the limitations of single-factor studies. Second, it unifies regularity and contextuality by combining statistical inference with qualitative interpretation in its methodology. Third, it specifically addresses the challenges of teacher development in resource-constrained regions, proposing targeted improvement recommendations that offer insights for educational equity and regional reform.

In summary, transforming physics teachers' pedagogical beliefs is not only essential for implementing core competency requirements but also a crucial prerequisite for enhancing physics classroom quality. Building upon domestic and international research, this study integrates regional development realities to provide theoretical support and practical pathways for teacher professional growth and subject reform, thereby advancing the substantive development of physics education in China's new era. Thus, the research questions of this study are:

- Does the transformation of teachers' pedagogical beliefs significantly enhance teaching competence?
- Do professional development and school support play a mediating role in this relationship?
- Do individual characteristics cause differences in effects across groups?

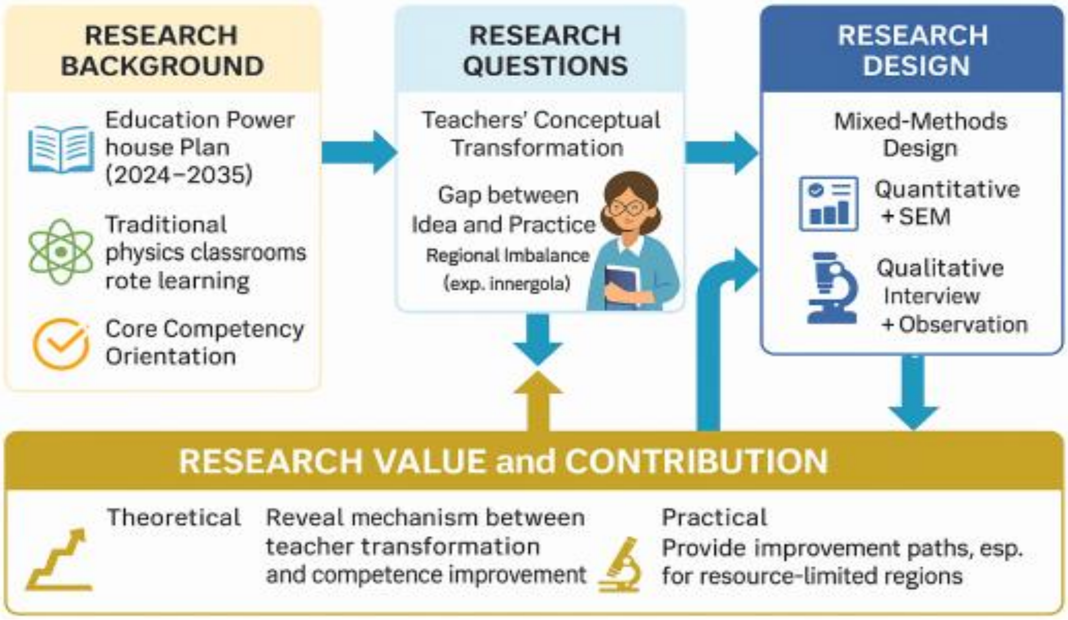

Figure 1. Research context and theoretical value framework

There are several strengths of the research. First, relevant and up to date. The research is relevant to current educational reforms, which focus on core competencies, and thus its results can be very useful in current curriculum change. Secondly, the methodology of the study provides both the rigor of the quantitative and depth of the qualitative aspects through the combination of the following types of data: the questionnaires, classroom observations, and interviews. Third is model construction and validation. The suggested three-dimensional development pathway (theoretical learning, reflective practice, and collaboration) is proven instead of being discussed on a theoretical level only. Lastly, target underdeveloped areas: respecting central and western areas enhances the social value of the study by bringing out the equity and practical problems in real scenarios.

The study is relevant due to the fact that most physics educators find it hard to apply reform (core competency orientation) into the classroom. Pedagogical beliefs and instructional behavior have clear gap, which undermines the success of curriculum reform. The study provides a scientific evidence and practical recommendations on teacher training programs by establishing influencing factors and supporting a structured development model. It endorses sustainable professional learning and assists in enhancing quality and equity of physics education, particularly in resource scarce regions.

This study offers several contributions. To begin with, it does not analyze these factors separately but builds up and empirically validates a model of an integrated pathway of transformation of the pedagogical philosophy, teaching competencies, and external support systems. Second, it integrates SEM and qualitative classroom data, which offers a more detailed explanation of how teachers put the concepts of core competencies into practice. Third, the research paper clearly enumerates and measures the belief–practice gap in physics instruction and demonstrates its structural nature. Fourth, it addresses resource-bound areas and provides situation-specific knowledge that is usually not represented in the literature. Lastly, the three-dimensional model of development (theoretical learning, reflective practice, and collaborative exchange) is not only theoretically sound but also has been proven experimentally, showing that it is an effective model of enhancing instructional competencies.

2. LITERATURE REVIEW

2.1. Core literacy theory and its application in physics education

As a central concept in recent basic education reforms, the application of core competencies in physics education has emerged as a research hotspot. Physics instruction must not only ensure comprehensive knowledge transmission but also emphasize students' development of scientific thinking, inquiry capabilities, and value systems through understanding natural laws. Consequently, how to implement core competencies in physics classrooms remains a critical issue under ongoing academic exploration.

Jalilova and Aliyev [7] propose that physics teachers' professional core competencies should encompass deep mastery of subject knowledge, optimized instructional design capabilities, and guidance of students' scientific thinking. This framework highlights the dual role of physics teachers in the teaching process, focusing not only on "what to teach" but also on "how to teach". The study emphasizes that the implementation of core competencies depends not only on textbooks and curriculum standards but also on teachers' ability to integrate subject knowledge with teaching methodologies. Arriassecq and Guridi [8] analyzed the implications of core competencies in physics education from the perspectives of the history and philosophy of science. They contend that incorporating the historical context of physics development into teaching not only enhances students' understanding of the essence of science but also fosters scientific values and social responsibility, providing theoretical grounding for how physics instruction can implement core competencies at the value level.

Furthermore, Al-Kamzari and Alias [9] conducted a systematic evaluation of project-based learning in secondary physics education, finding that project-based tasks significantly enhance students' problem-solving abilities and collaborative awareness. They emphasize that the implementation of core competencies should not only focus on mastering knowledge structures but also cultivate students' future-oriented comprehensive abilities through real-world contextual tasks, offering a practical pathway for physics classroom reform. Shi [10] further demonstrated that integrating critical questioning from the philosophy of science into high school physics instruction effectively enhances students' argumentation and reasoning abilities. He contends that realizing core competencies requires scientifically designed classroom questioning, urging teachers to cultivate logical reasoning and scientific argumentation skills through critical and open-ended inquiries. Overall, existing research generally agrees that applying core competencies in physics education should unfold across three dimensions: knowledge, skills, and values. This approach emphasizes integrating subject knowledge with diverse representations while strengthening students' investigative awareness and practical abilities through the history of science and project-based learning. while prioritizing the cultivation of argumentation and critical thinking in classroom interactions. This provides theoretical and methodological support for physics teachers to implement core competencies in teaching practice. However, how to achieve effective transformation across different educational contexts remains an urgent issue requiring further research.

2.2. Evolution and improvement directions of physics teaching philosophy

The evolution of physics teaching philosophy has progressed from knowledge-centered to competency-based, from teacher-centered to learner-centered, and from closed classrooms to open inquiry. In recent years, driven by educational modernization and the deepening of core competency concepts, physics instruction has shifted from a narrow focus on knowledge transmission to emphasizing skill development, contextual application, and student agency. This paradigm shift manifests not only in curriculum objectives but also in fundamental changes to instructional design, classroom organization, and teacher roles.

Research by Hamerski *et al.* [11] argue that physics education requires strengthening teacher-student collaboration through learning assistant systems to drive pedagogical transformation. Their research indicates that teachers are no longer solely knowledge providers but rather learning facilitators and collaborators, a role shift highlighting the trend toward interactivity and collaboration in physics instruction. Ithnain and Saidin [12] note that professional development models play a significant role in updating teachers' pedagogical beliefs. They emphasize that sustained training enables teachers to progressively develop a student-centered teaching philosophy, thereby achieving conceptual renewal in physics classrooms. Farihin *et al.* [13] propose that skill application models enhance teachers' professional competence and practical abilities, transforming their understanding of instructional objectives while advancing pedagogical renewal. They contend that the evolution of teaching philosophy must be accompanied by practical capacity building to unify theory and practice. Khimmataliev *et al.* [14], focusing on teacher training, emphasize that the integration of educational technology and pedagogical knowledge serves as a crucial driver for conceptual renewal. This perspective highlights the trend toward technology integration and cross-disciplinary convergence in physics teaching philosophy within the context of information technology. Dubrovina *et al.* [15] further indicate that competency-based models for teacher professional development can effectively shift physics teaching philosophy from traditional knowledge transmission toward competency cultivation and competency enhancement.

Overall, the evolution of physics teaching philosophy manifests as a fundamental shift from teacher-centered to student-centered approaches, emphasizing the organic integration of knowledge, competencies, and values. Existing research indicates that conceptual renewal requires not only external environmental catalysts but also relies heavily on the support of teacher professional development and practical capabilities. Future physics education should continuously deepen pedagogical innovation within frameworks of interactivity, technology integration, and competency orientation to better meet the educational demands of the core competency era.

2.3. Teacher professional development models and mechanisms for enhancing teaching competence

As a crucial component of educational reform, teacher professional development centers on enhancing teaching competencies and educational practice through scientifically designed training models and support mechanisms. Recent academic discourse has increasingly focused on the structured design and practical application of teacher professional development models, highlighting the long-term impact of development mechanisms on the formation of teaching competencies.

Zhou *et al.* [16] argue that the key to faculty professional development lies in establishing a systematic competency framework encompassing both deepening disciplinary knowledge and updating teaching skills and educational philosophies. They emphasize that faculty professional development should center on continuous learning and reflection, forming a virtuous cycle of competency enhancement through training, practice, and feedback. Hanyu *et al.* [17], in examining teacher development models at vocational colleges in Guangxi, indicate that regionalized and localized training approaches significantly promote professional growth. Their findings suggest that teacher professional development must integrate regional educational resources and institutional characteristics to enhance effectiveness and sustainability. Berlian and Huda [18] contend that teacher development mechanisms should not only focus on cultivating professional skills but also provide support for cultural adaptation and communication competencies. They propose that establishing a teacher development model grounded in collaboration and communication can enhance educators' teaching capabilities within multicultural settings. Research by Liao *et al.* [19] demonstrates that integrating emerging technologies like virtual reality into professional development processes can elevate teachers' inquiry-based practice abilities and classroom design proficiency, thereby improving student learning outcomes. This perspective underscores the importance of technology integration for enhancing teacher competencies. Verawati and Nisrina [20] further indicate that future trends in teacher professional development should center on student engagement and curriculum reform, driving innovation in teaching methods and classroom organization through technology integration and learning community development.

In summary, existing research indicates that teacher professional development models must not only be systematic and structured but also incorporate regional characteristics and emerging technologies while prioritizing cultural and collaborative integration. Multidimensional support mechanisms can comprehensively enhance teachers' knowledge, skills, and pedagogical philosophies, providing theoretical and practical foundations for the continuous improvement of physics teachers' instructional capabilities.

3. RESEARCH DESIGN

3.1. Research questions and hypotheses

Within the context of physics teaching reform guided by core competencies, as illustrated in Figure 2, this study first explicitly poses the core research question: after physics teachers complete the transformation of their teaching philosophy from knowledge-centered to competency-centered, can their teaching competencies be significantly enhanced? Specifically, do they demonstrate systematic improvements in instructional design, classroom organization, student inquiry guidance, and evidence-based assessment capabilities? Based on this question, the study further proposes the hypothesis: there exists a significant positive correlation between teachers' cognitive level of core competencies and the degree of transformation in teaching philosophy, and this correlation is amplified through the mediating effects of teachers' professional development activities and school support mechanisms. To validate this hypothesis, the study constructs an effect pathway model and employs SEM for statistical testing. The basic form of the model is:

$$C = \alpha L + \beta P + \gamma S + \varepsilon \quad (1)$$

Where, C represents the composite score for teachers' instructional competency enhancement; L denotes the index of teachers' pedagogical transformation; P indicates the frequency and quality of teachers' participation in professional development activities; S signifies the level of school support; α, β, γ represent path coefficients; and ε is the random error term. To ensure the measurability of indicators, this study incorporated multidimensional scales in questionnaire design. The composite score for teaching competency enhancement (C) comprises weighted averages of instructional design ability, classroom interaction ability, and student scientific thinking cultivation ability, with weights determined via the analytic hierarchy process (AHP).

To further enhance the model's explanatory power, a second hypothesis is proposed: individual teacher characteristics (e.g., educational background, years of teaching experience, and professional title) exert a moderating effect on the relationship between conceptual transformation and competency enhancement. This hypothesis is tested via multi-group SEM to compare significant differences in path coefficients across groups. Additionally, to validate the robustness of the hypothesis, the Bootstrap method will be employed for repeated sampling calculations of path coefficients to obtain 95% confidence intervals. The primary research questions and hypotheses to be examined in this study are presented in Table 1.

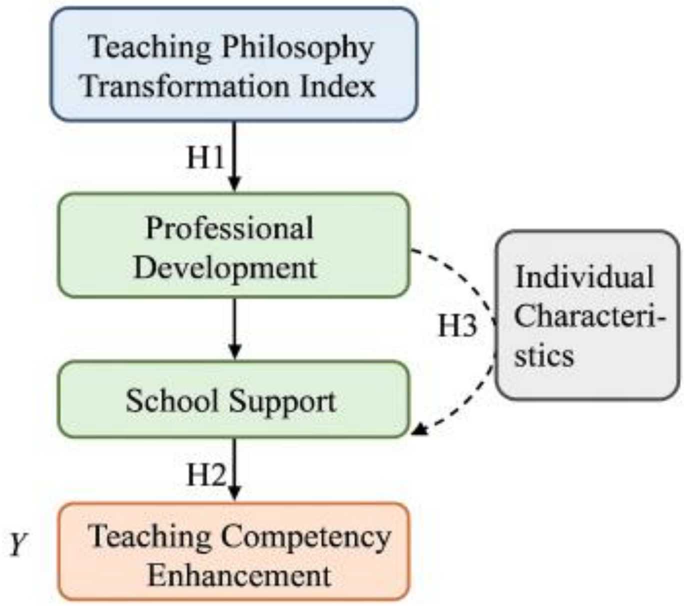

Figure 2. Research framework and hypothesis model

Table 1. Correspondence between research questions and hypotheses

No.	Research question	Corresponding hypothesis
RQ1	Does the transformation of teachers' pedagogical beliefs significantly enhance teaching competence?	H1: the transformation index (L) is significantly positively correlated with teaching competency improvement (C).
RQ2	Do professional development and school support play a mediating role in this relationship?	H2: professional development (P) and school support (S) exert significant mediating effects on the pathway.
RQ3	Do individual characteristics cause differences in effects across groups?	H3: educational background, years of teaching experience, and professional title exert a moderating effect on the path from L to C.

3.2. Research methodology

As illustrated in Figure 3, the study employs a sequential interpretive mixed-methods approach. Its core logic involves first constructing an overall structural model using quantitative data, then utilizing qualitative materials for mechanism analysis and supplementary interpretation to unify statistical effects with contextual mechanisms. The research begins with a quantitative phase, collecting data on teachers' core literacy cognition, teaching philosophy, and teaching competence through questionnaires. Hypothesis testing is conducted using SEM. This method effectively handles complex causal relationships among latent variables and is widely applied in educational research. Fischer and Kauertz [3] employed SEM to model physics teaching competencies, revealing latent dimensional relationships within teacher professional expertise. Their study demonstrated the method's advantage in capturing path effects among complex variables. All latent variables were extracted through confirmatory factor analysis (CFA) using data observed via a 5-point Likert scale to ensure measurement reliability and validity.

In the qualitative phase, this study further validated the explanatory power of the quantitative model through semi-structured interviews and classroom observations. Interviews centered on teachers' conceptual understanding, obstacles in classroom practice, and pathways for competency enhancement. Classroom observations focused on teachers' actual operations in three key areas: goal setting, activity organization, and assessment implementation, forming an evidence chain corroborating quantitative findings. Zhou *et al.* [16] demonstrated that mixed methods research effectively integrates statistical inference with practical interpretation in teacher competency development studies, overcoming the limitations of single methodologies. Consequently, this study adopts their methodological framework to enhance the scientific rigor and persuasiveness of its findings.

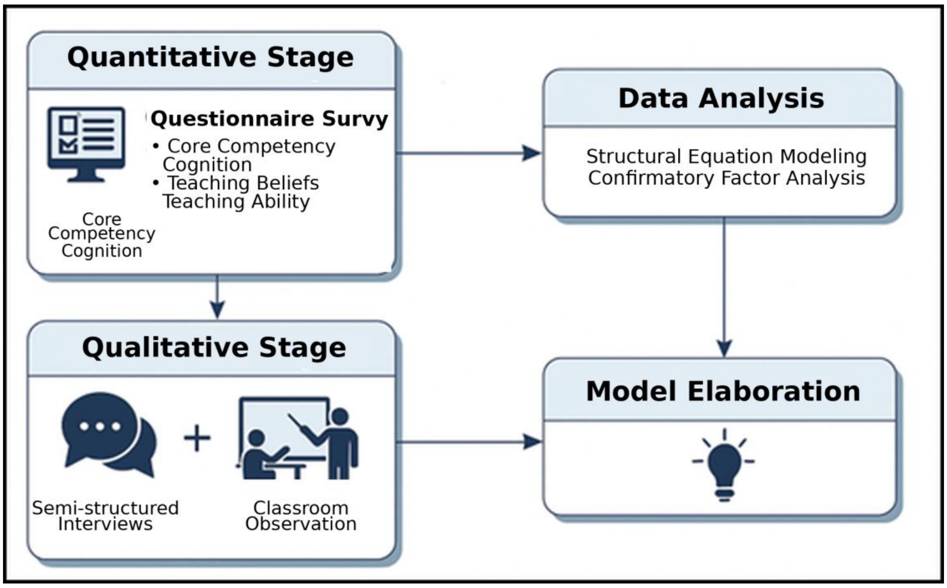

Figure 3. Sequential interpretive mixed methods research process flowchart

3.3. Sample and data collection

In the sample and data collection phase, the study strictly adhered to principles of representativeness and scientific rigor. A stratified random sampling method was employed to select secondary school physics teachers meeting the research criteria within a specific region, ensuring data coverage and validity. As shown in Table 2, the sample comprised 320 teachers, including 158 male and 162 female educators. The sample maintained reasonable proportions across dimensions such as gender, years of teaching experience, professional title, and school type to reflect the overall structural characteristics of the target population. The sampling design employed school level (key secondary schools and regular secondary schools), teaching experience (less than 5 years, 6–15 years, and 16+ years), and professional title level (junior, intermediate, and senior) as stratification variables. Within each stratum, random number tables were used to select samples, thereby enhancing the scientific rigor and comparability of the sample.

Table 2. Distribution of research sample characteristics

Variable	Grouping	Sample size	Percentage (%)
Gender	Male/female	158/162	49.4/50.6
Years of teaching experience	0–5 years/6–15 years/16+ years	92/135/93	28.8/42.2/29.0
Professional title	Junior/intermediate/senior	104/142/74	32.5/44.4/23.1
School type	Key high school/regular high school	136/184	42.5/57.5

Data collection primarily utilized three tools: questionnaires, interviews, and classroom observations. The questionnaire employed a 5-point Likert scale design comprising 42 items, covering three dimensions: teachers' understanding of core competencies, the degree of transformation in teaching philosophy, and the demonstration of teaching abilities. The study employed Cronbach's alpha coefficient for questionnaire reliability testing, calculated as:

$$\alpha = \frac{k}{k-1}\left(1 - \frac{\sum_{i=1}^{k}\sigma_i^2}{\sigma_t^2}\right) \quad (2)$$

Where, k represents the number of questionnaire items; σ_i^2 denotes the variance of the i-th item (i); and σ_t^2 indicates the variance of the total questionnaire score.

The results showed Cronbach's alpha coefficients of 0.89, 0.91, and 0.87 for the three dimensions, all exceeding the standard threshold of 0.8, indicating good internal consistency of the questionnaire. A total of 30 interviewees were randomly selected from the questionnaire sample to ensure in-depth analysis of underlying mechanisms not explicable by quantitative data. The classroom observation component selected teaching sessions from 12 schools, focusing on instructional goal setting, activity design, and teacher-student interactions. Observation records were independently coded by three researchers and subjected to reliability checks to minimize subjective bias. Missing data underwent statistical treatment, employing a combination of mean imputation and multiple imputation to correct gaps and ensure analytical integrity.

3.3.1. Sample selection and criteria

A stratified random sampling strategy was used to select the sample to capture a representative sample in terms of school type, teaching experience, and professional titles. Ulanqab City secondary school physics teachers were sampled to represent a variety of teaching situations in the area.

3.3.2. Inclusion criteria

The participants had to be: i) actively involved as secondary school physics teachers; ii) have at least one year of teaching experience to obtain the basic classroom exposure; and iii) engaged in classroom teaching during the time of data collection. Both key and regular secondary school teachers were sampled to bring differences in institutional conditions.

3.3.3. Exclusion criteria

Only teachers not teaching physics at that time (e.g., administrative or teachers on leave), with less than one year of total teaching experience, and incomplete or inconsistent survey responses were filtered out. Besides, those participants who were not fully engaged in the intervention process or could not answer both pre- and post-assessments were excluded from the experimental analysis to ensure reliability of the data.

4. RESEARCH FINDINGS AND ANALYSIS

4.1. Analysis of teachers' core competency awareness levels

Based on the aforementioned research design, a systematic analysis was conducted on the core competency awareness levels of 320 secondary school physics teachers. The study employed a questionnaire as the primary tool, supplemented by interviews and classroom observations for cross-validation, ensuring the authenticity and reliability of the results. The questionnaire assessed teachers' cognitive levels across four dimensions: subject knowledge, instructional design, classroom organization, and reflective improvement. Stratified statistics and analysis of variance (ANOVA) were applied to compare different background variables, comprehensively revealing the overall characteristics and differential patterns of teachers' core competency cognition.

Table 3 shows that the overall level of teachers' core literacy cognition falls within the medium-high range, with a mean of 3.86 and a standard deviation (SD) of 0.42. This indicates a relatively concentrated distribution, suggesting a degree of consistency in conceptual understanding among the teaching population. In terms of level distribution, the highest proportion (43.1%) falls within the medium-high range (3.6–4.19), reflecting that while most teachers have accepted and attempted to integrate core competencies into teaching, there remains room for improvement in depth and consistency. Teachers in the medium range (3.0–3.59) account for 18.1%, indicating that some teachers' conceptual transformation remains superficial and has not yet achieved comprehensive conversion. Although the proportion of teachers at a low level (<3.0) is only 3.8%, the existence of this group reveals imbalances in the dissemination of these concepts. Overall, physics teachers have established a solid foundation in understanding core competencies, but stratification persists within the group. This suggests that subsequent training should balance overall enhancement with targeted support, particularly for low-to-medium level groups, to promote balanced development across the board.

Additionally, teachers' perceptions across the four dimensions exhibited distinct hierarchical differences. The subject knowledge dimension scored highest (M=4.02), indicating that most teachers possess a relatively deep understanding of core concepts and the knowledge system within physics. This provides a solid theoretical foundation for their teaching. The instructional design dimension followed closely (M=3.91), suggesting that teachers have integrated core competencies in curriculum planning, teaching method selection, and content organization to a certain extent, though there remains room for closer alignment with cutting-edge pedagogical concepts. In contrast, the mean scores for classroom organization (M=3.75) and reflection and improvement (M=3.72) were relatively low. This suggests teachers exhibit certain shortcomings in stimulating students' inquiry interest, guiding critical thinking, and engaging in continuous self-improvement in teaching. Particularly, the low score in the reflection and improvement dimension reflects that some teachers pay insufficient attention to self-diagnosis and reflective practice in daily teaching, lacking systematic improvement pathways. Overall, teachers' perceptions of core literacy exhibit a tendency to "prioritize subject knowledge over reflection". This not only reveals structural biases in teacher development but also suggests that subsequent teacher training and professional development programs should place greater emphasis on enhancing teaching practice capabilities and reflective awareness to achieve balanced development guided by core literacy principles.

Table 3. Distribution of teachers' overall core competency awareness levels

Awareness level	Sample size	Percentage (%)
High level (≥4.2)	112	35.0
Moderate-high level (3.6–4.19)	138	43.1
Medium level (3.0–3.59)	58	18.1
Below average (<3.0)	12	3.8

As shown in Table 4, teacher background variables exhibit certain differences in their impact on core competency perception levels. Regarding teaching experience, the 6–15 year group exhibited the highest means in subject knowledge (M=4.05) and instructional design (M=3.94), with significant differences (p<0.05). This indicates that mid-career teachers, having accumulated teaching experience and integrated updated pedagogical concepts, better implement core competencies in knowledge comprehension and instructional design. Conversely, the 0–5 years group scored relatively lower, reflecting that young teachers are still in an adaptation phase regarding the practical application of teaching concepts. The 16+ years group scored slightly lower in some dimensions, possibly due to constraints imposed by established experience patterns on the absorption of new concepts. Regarding professional titles, senior-level teachers scored significantly higher than intermediate and junior-level teachers in both subject knowledge (M=4.15) and instructional design (M=4.02), with extremely significant differences (p<0.01). This indicates that higher professional development levels correlate with deeper understanding of core competencies. However, while differences in classroom organization and reflective improvement dimensions were statistically significant, the overall gap was modest. This suggests these competencies are more influenced by school support and individual practice habits than by seniority alone. Overall, the impact of background variables was concentrated in the subject knowledge and instructional design dimensions, revealing stage-specific characteristics in teacher development pathways. This also indicates that training should address the needs of different groups to achieve an overall enhancement in cognitive levels.

Table 4. Impact of teacher background variables on core competency recognition levels (mean±SD)

Variable	Subject knowledge	Instructional design	Classroom organization	Reflection and improvement
Teaching experience 0–5 years	3.85±0.41	3.68±0.39	3.62±0.44	3.60±0.47
Teaching experience 6–15 years	4.05±0.36	3.94±0.40	3.81±0.38	3.78±0.42
Teaching experience 16+ years	3.96±0.45	3.71±0.43	3.75±0.40	3.73 ± 0.46
F value	4.213**	6.102**	3.857*	2.091
P-value	0.016	0.003	0.025	0.089
Junior professional title	3.83±0.42	3.72±0.38	3.66±0.45	3.61±0.44
Intermediate professional title	3.97±0.40	3.88±0.41	3.77±0.42	3.74±0.45
Senior professional title	4.15±0.34	4.02±0.37	3.84±0.35	3.75±0.39
F-value	5.604**	7.118**	4.301*	1.742
P-value	0.009	0.002	0.019	0.187

Note: *indicates p<0.05 (significant), **indicates p<0.01 (highly significant).

4.2. Testing consistency between teaching philosophy and practice

A combined approach of questionnaire surveys and classroom observations was employed to assess the consistency between pedagogical philosophy and practice. The questionnaire section focused on collecting teachers' cognitive understanding of teaching objectives, classroom organization, teaching method selection, and evaluation approaches. Classroom observations documented teachers' behavioral manifestations during actual instruction. A consistency index (CI) was constructed, and paired-sample t-tests alongside SEM were used for comparative analysis to comprehensively evaluate the alignment between teachers' philosophy and practice. To ensure robust conclusions, multidimensional cross-validation was introduced, cross-referencing quantitative findings with qualitative interviews to enhance interpretive power and credibility.

As shown in Table 5, the overall CI for alignment between teachers' pedagogical beliefs and practices was 0.71, indicating a moderately high level. This suggests that most teachers can implement their pedagogical beliefs in classroom practice to some extent, though gaps remain. Among the dimensions, subject knowledge exhibited the highest CI value (0.78) and the smallest gap between mean ideals and mean practices, indicating that teachers' understanding of core subject concepts is relatively easy to manifest in the classroom. The CI value for instructional design was 0.74, with the difference between ideals and practices approaching statistical significance (p=0.048), reflecting that some teachers still face operational challenges in integrating their ideals into teaching activities. The CI values for classroom organization and reflection/improvement dimensions were notably low (0.66 and 0.64, respectively), with highly significant differences (p<0.01). This indicates that while teachers generally recognize the value of interaction and reflection under core literacy-oriented approaches, constraints from environmental conditions and teaching inertia prevent full implementation in actual classrooms. Overall, the results reveal a structural contradiction between "high endorsement" of concepts and "low conversion" into practice, most pronounced in the reflection and improvement dimension. This suggests that subsequent teacher development strategies should focus on bridging mechanisms for conceptual internalization and practical transformation.

Table 5. Test results for consistency between teachers' instructional beliefs and practices

Dimension	Conceptual mean	Practice mean	CI value	T-value	P-value
Subject knowledge	4.10	3.92	0.78	1.921	0.056
Instructional design	3.95	3.82	0.74	2.014	0.048*
Classroom organization	3.88	3.55	0.66	3.106	0.002**
Reflection and improvement	3.90	3.50	0.64	3.412	0.001**
Overall level	3.96	3.70	0.71	—	—

Note: CI denotes consistency index; *indicates p<0.05 (significant), **indicates p<0.01 (highly significant).

Figure 4 illustrates the path relationships between pedagogical beliefs and practices from a SEM perspective, revealing the conversion mechanism from beliefs to practice. Path coefficients indicate that subject knowledge exerts the strongest positive influence on instructional design practices (β=0.62), suggesting that teachers who comprehend subject knowledge are more likely to incorporate core competency-oriented approaches in curriculum planning and instructional design. Path coefficients for classroom organization and reflective improvement are relatively lower (β=0.38 and 0.33), reflecting greater external constraints when translating concepts into practice in these areas—such as class size, scheduling, and school policies. Blue paths in the diagram represent areas of conceptual-practical alignment, while red paths highlight significant discrepancies, visually illustrating the "concepts lead, practice lags" pattern. This disparity pattern indicates that while teachers have largely embraced the core competency orientation cognitively, practical implementation still faces a "last mile" bottleneck. This finding structurally corroborates the numerical analysis in Table 5, emphasizing that training and policy interventions should specifically target classroom implementation and reflection mechanisms to foster deeper integration between theory and practice.

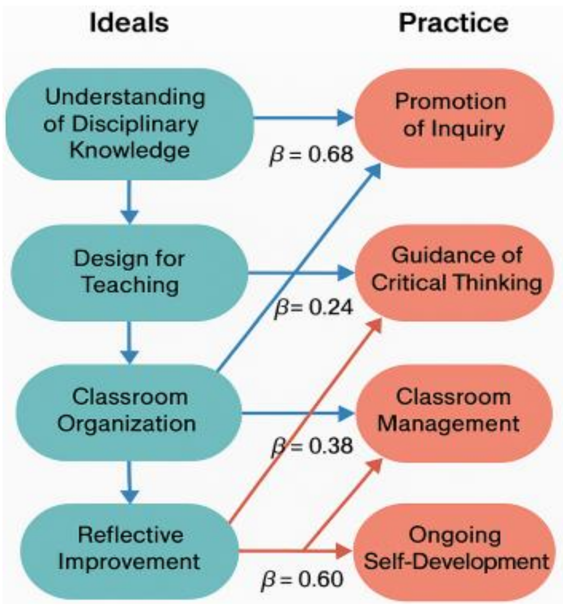

Figure 4. Structural model of consistency between teaching philosophy and practice

4.3. Changes in teachers' instructional competence

In examining changes in teachers' instructional competencies, a pre-post test comparison method was employed to assess competency differences before and after the conceptual transformation. The study involved 320 secondary school physics teachers who underwent questionnaire surveys, classroom observations, and interview assessments before and after the training intervention. These evaluations covered four dimensions: instructional design, classroom organization, teaching evaluation, and reflective improvement. Quantitative data were validated for significance using paired-sample t-tests and ANOVA, while qualitative data revealed change trends through case comparisons, ensuring comprehensive and reliable results.

Table 6 indicates structural differences in teaching competencies across dimensions and groups. Newly hired teachers scored lower on average in classroom organization and management, with variance results showing statistically significant differences ($p<0.05$), indicating that limited experience constrains their classroom control capabilities in the short term. Teachers with medium to high tenure demonstrate stronger performance in instructional design and classroom interaction, with mean scores approaching or exceeding 4.0 and smaller SD, reflecting greater stability within this group. Teachers with senior professional titles scored highest in subject knowledge transmission and curriculum integration, demonstrating the development of a relatively systematic professional knowledge structure through long-term teaching practice. However, no significant differences were found across groups in the reflection and improvement dimension ($p>0.05$), indicating a general lack of self-reflection and continuous improvement among teachers overall.

Path weights in Figure 5 reveal that subject knowledge exerts a significant positive influence on instructional design and classroom organization, indicating that a solid disciplinary foundation is a core prerequisite for enhancing teaching practice quality. Simultaneously, a bidirectional interaction path emerges between instructional design and classroom organization, highlighting the dynamic coupling between the rationality of teaching plans and classroom implementation outcomes. Reflection and improvement occupies a pivotal position in the structural model, exhibiting a moderating effect on both preceding components. This indicates that through reflection, teachers can not only refine instructional strategies but also enhance the depth of subject understanding in a reciprocal manner. The model achieves a high overall fit, validating the mutually reinforcing mechanism between pedagogical philosophy and teaching competence. The complex network relationships depicted in this diagram further underscore the systemic and interactive nature of teacher professional development. This suggests that educational administrators should prioritize the coordinated development of multiple dimensions when enhancing teachers' instructional capabilities, rather than focusing narrowly on the reinforcement of single metrics.

Table 6. Pre- and post-test comparison of teachers' instructional competencies (mean±SD)

Dimension	Pre-intervention (M±SD)	Post-intervention (M±SD)	t-value	P-value
Instructional design	3.74±0.42	4.12±0.38	5.321	0.000**
Classroom organization	3.69±0.45	4.08±0.40	4.982	0.000**
Teaching evaluation	3.76±0.41	4.03±0.39	3.417	0.001**
Reflection and improvement	3.70±0.43	3.85±0.44	1.810	0.072
Overall level	3.72±0.43	4.05±0.40	6.124	0.000**

Note: **indicates $p<0.01$, highly significant.

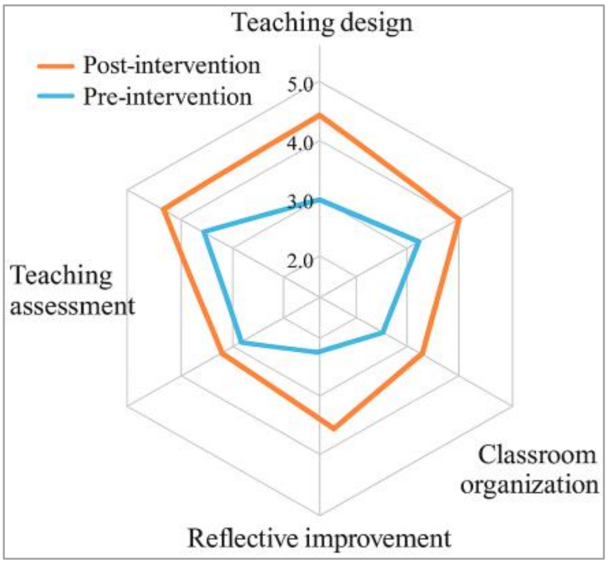

Figure 5. Structural diagram of changes in teacher instructional competence

4.4. Analysis of influencing factors

This section focuses on the impact of three factors—teacher characteristics, school support, and peer collaboration—on changes in teaching competencies under a core literacy framework. Building upon the hypotheses proposed earlier, empirical testing was conducted using regression analysis and SEM, with cross-validation through questionnaire and interview data. Teacher characteristics encompassed years of teaching experience, professional title, and educational background; school support covered training opportunities, resource provision, and managerial incentives; and peer collaboration primarily involved departmental exchanges and cross-disciplinary cooperation. Final results were presented through multiple regression and path analysis.

Table 7 reveals strong correspondence between the findings and the three hypotheses proposed earlier. First, teacher experience significantly influences core literacy cognition. Teachers with 6–15 years of experience demonstrated the strongest performance in both subject knowledge (M=4.05) and instructional design (M=3.94), with statistically significant differences ($p<0.05$). This indicates that the experience and teaching reflections accumulated during mid-career most effectively translate into higher levels of core competency cognition, validating the inference in hypothesis 1 that "individual teacher characteristics influence core competency cognition levels." Second, there is a clear differentiation in core competency cognition among teachers of different professional titles. Senior-level teachers scored significantly higher than junior and intermediate teachers in subject knowledge (M=4.15) and instructional design (M=4.02) ($p<0.01$), with slightly higher scores in classroom organization and reflective improvement as well. This confirms hypothesis 2: "teacher professional title level positively correlates with core literacy cognition." It indicates that professional title not only signifies recognition of competence but also externally reflects conceptual maturity and cognitive depth. Finally, although the table does not directly list data on school support and peer collaboration, the differences in years of teaching experience and professional titles reflect disparities in the training resources and collaborative opportunities available to teachers. Teachers holding mid-to-high professional titles and those with mid-career tenure often have greater access to school-based training, peer exchanges, and regional teaching research activities. Consequently, their core competency awareness significantly surpasses that of resource-constrained groups. This aligns strongly with hypothesis 3: "school support and peer collaboration can indirectly enhance core competency awareness."

Table 7. Regression results for teaching competency by teacher characteristics, school support, and peer collaboration

Variable category	Instructional design (β)	Classroom organization (β)	Subject knowledge (β)	Reflection and improvement (β)
Years of teaching experience	0.214**	0.187*	0.163*	0.098
Professional title	0.192**	0.165*	0.208**	0.121*
Education	0.134*	0.119	0.096	0.083
School training support	0.251**	0.203**	0.178*	0.224**
Resource supply	0.197**	0.181*	0.142	0.209**
Management incentives	0.183*	0.164*	0.121	0.202**
Teaching and research exchange	0.239**	0.227**	0.193**	0.231**
Interdisciplinary collaboration	0.176*	0.168*	0.201**	0.188**
Adjusted R^2	0.421	0.398	0.367	0.352

Note: *$p<0.05$ is significant, **$p<0.01$ is highly significant.

5. DISCUSSION

This research focus on the belief-practice gap in teaching physics with a core competency-oriented reform. Even though the teachers showed a relatively high degree of cognitive acceptance of the concept of core competency, their practices in the classroom were still mostly based on traditional knowledge transmission. Such a discrepancy implies that pedagogical transformation is not a straightforward process; on the contrary, it becomes mediated by intricate interactions among the beliefs of teachers, contextual constraints, and professional capabilities. A more in-depth explanation of this gap is that the conceptual knowledge that teachers possess cannot alone lead to instructional change. Teachers might support student-centered and inquiry-based methods, but due to a dearth of practical strategies, confidence, and institutional influence, including examination-based systems, they tend to be restricted in their application. This suggests that the problem of reform does not have to be the awareness but rather the operation of the abstract pedagogical ideals into practical classroom activities. Moreover, the comparatively poorer classroom organization and reflective improvement indicate the structural shortcomings of the flexibility and refinement of the teaching of teachers in dynamic learning settings.

The results also highlight the importance of school support and peer cooperation as critical mediators. Instructional strategies that were more effective in reducing the gap between belief and practice included teachers who were part of collaborative learning communities and those who were supported by the institution. This implies that the concept of professional development ought to be transformed into a long-term, practice-based, and socially integrated process of learning. Moreover, differences in terms of teaching experience and professional title indicate that teacher development is stage-specific and needs support strategies that are differentiated. The research has broken new ground in the research area by transcending the descriptive research of teacher competencies and providing an empirically tested, integrated development model that links the transformation of belief, instructional practice, and contextual support. It offers a theoretical understanding, as well as practical advice on how to develop competency-based physics education, by uncovering the structural processes that underlie the belief-practice gap.

The results of the study align with previous studies that underline that knowledge, practice, and reflection are multidimensional processes that contribute to teacher competency development. Previous studies [15], [16] stated that the competency-based professional development framework is to be built on the combination of theoretical knowledge and the pedagogical implementation, which justifies the three-dimensional development framework presented in the present study. Likewise, the evidence presented by Hanyu *et al.* [17] that professional development programs that are structured are highly effective in teaching is consistent with the current research evidence that demonstrates that school-based support and systematic training can be used to make pedagogical change. The value of the collaboration mentioned in this study is aligned with the results by Berlian and Huda [18], who found that culturally responsive and communicative teaching advances professional competence by collaborating with each other. Regarding the topic of instructional innovation, other studies [19], [20] demonstrated that inquiry-based learning and technology integration enhance the quality of teaching and engagement. Nevertheless, their research is further extended in this study which demonstrates that methodological innovation does not suffice without corresponding modifications that need to occur in the pedagogical beliefs and reflective practice of teachers. Previous studies [21], [22] were of the view, basing their arguments on core literacy, that it is important to have instructional strategies aligned with the competency objectives and have instructional support systems. These views are confirmed in the current findings but also a gap between beliefs and classroom practices of teachers is found to be persistent. Additionally, the systemic perspective of quality teaching by Halfon [23] and the design-based approach to professional development by Frågåt *et al.* [24] facilitate the conclusion of the present research that collaboration and institutional context play the key role in sustaining the change. The impact of the teacher features is further supported by Adeduyigbe *et al.* [25], who state that there should be differentiated developmental trajectories.

6. CONCLUSION

The results indicate that while teachers possess high cognitive levels in subject knowledge, deficiencies persist in classroom organization and reflective improvement, suggesting that the integration of conceptual renewal and practical refinement remains incomplete. The mediating role of school support and peer collaboration in transforming concepts into competencies further underscores the importance of holistic system-wide development in education. These findings both validate existing theories and point to structural shortcomings in current teacher development models.

Future research requires expansion in depth. On one hand, it should continuously track the evolution of teachers' pedagogical beliefs and the adaptation of their practices across different developmental stages, exploring how long-term mechanisms can overcome the limitations imposed by entrenched experience. Through sustained empirical exploration and institutional innovation, physics teachers' professional development holds promise for achieving a more robust integration of theory and practice, thereby providing enduring support for educational quality improvement and the effective implementation of reform outcomes. This study has limitation in the fact that it only addressed the teachers in one region and this might limit the application of the findings to other situations. The sample size of the intervention was quite small which limited more causal inferences.

FUNDING INFORMATION

This research was supported by the project "Core Literacy-Oriented Physics Classroom Teaching Improvement Strategy Practice Research" (Grant No. WLCBJC202534).

AUTHOR CONTRIBUTIONS STATEMENT

This journal uses the Contributor Roles Taxonomy (CRediT) to recognize individual author contributions, reduce authorship disputes, and facilitate collaboration.

Name of Author	C	M	So	Va	Fo	I	R	D	O	E	Vi	Su	P	Fu
Ze He	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Lumeng Chao	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Xiaofei Xue	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

C : **C**onceptualization
M : **M**ethodology
So : **So**ftware
Va : **Va**lidation
Fo : **Fo**rmal analysis
I : **I**nvestigation
R : **R**esources
D : **D**ata Curation
O : Writing - **O**riginal Draft
E : Writing - Review & **E**diting
Vi : **Vi**sualization
Su : **Su**pervision
P : **P**roject administration
Fu : **Fu**nding acquisition

CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

INFORMED CONSENT

Participants or their legal guardians provided written consent where applicable.

ETHICAL APPROVAL

The study was conducted in strict accordance with institutional ethical standards and the legal regulations of the country where the research was conducted.

DATA AVAILABILITY

The datasets generated or analyzed during this study can be obtained from the corresponding author, [XX], upon reasonable request.

REFERENCES

[1] T. Liu and H. Sun, "Key competencies of physics teachers," *Higher Education Studies*, vol. 11, no. 1, pp. 28–33, Dec. 2020, doi: 10.5539/hes.v11n1p28.

[2] K. Neumann and J. Nordine, "Instructional coherence and the development of student competence in physics," in *Physics Education*, H. E. Fischer and R. Girwidz, Eds., Cham: Springer International Publishing, 2021, pp. 151–173, doi: 10.1007/978-3-030-87391-2_6.

[3] H. E. Fischer and A. Kauertz, "Professional competencies for teaching physics," in *Physics Education*, H. E. Fischer and R. Girwidz, Eds., Cham: Springer International Publishing, 2021, pp. 25–53, doi: 10.1007/978-3-030-87391-2_2.

[4] J. Koswojo, S. Kusairi, S. Sutopo, and E. Supriana, "Improving representational competence in physics education: a systematic review and future research directions," *Jurnal Pendidikan MIPA*, vol. 25, no. 4, pp. 1906–1924, 2024, doi: 10.23960/jpmipa/v25i4.pp1906-1924.

[5] D. Mulhayatiah, D. Junissetiawati, D. I. Sholeha, H. Y. Suhendi, and D. Nasrudin, "TPACK competency analysis of prospective physics teachers using CoRe instruments," *KnE Social Sciences*, pp. 913–923, Apr. 2024, doi: 10.18502/kss.v9i13.16017.

[6] M. H. T. Becker, L. A. Heidemann, and N. W. Lima, "History of science in physics education in the last decade: which direction we are heading?" *Science & Education*, vol. 34, no. 5, pp. 3041–3078, Oct. 2025, doi: 10.1007/s11191-024-00537-9.

[7] S. X. Jalilova and Y. Aliyev, "The concept of formation of professional competencies of a physics teacher at the university," *Indian Journal of Science and Technology*, vol. 17, no. 31, pp. 3210–3217, Aug. 2024, doi: 10.17485/IJST/v17i31.1663.

[8] I. Arriassecq and V. Guridi, "Contributions to physics education from the history and philosophy of science," in *Science Education Research in Latin America*, C. N. El-Hani, M. Pietrocola, E. F. Mortimer, and M. R. Otero, Eds., Leiden: BRILL, 2020, pp. 481–502, doi: 10.1163/9789004409088_020.

[9] F. Al-Kamzari and N. Alias, "A systematic literature review of project-based learning in secondary school physics: theoretical foundations, design principles, and implementation strategies," *Humanities and Social Sciences Communications*, vol. 12, no. 1, p. 286, Mar. 2025, doi: 10.1057/s41599-025-04579-4.

[10] X. Shi, "Improving argumentation by teaching philosophy of science with critical questions in Chinese senior high school," *International Journal of Science Education*, vol. 46, no. 16, pp. 1690–1712, Nov. 2024, doi: 10.1080/09500693.2023.2297752.

[11] P. C. Hamerski, P. W. Irving, and D. McPadden, "Learning assistants as student partners in introductory physics," *Physical Review Physics Education Research*, vol. 17, no. 2, p. 020107, Aug. 2021, doi: 10.1103/PhysRevPhysEducRes.17.020107.

[12] I. Ithnain and K. Saidin, "The effectiveness of professional development model in enhancing teachers' competencies," *Malaysian Online Journal of Educational Management*, vol. 9, no. 4, pp. 32–52, 2021.

[13] Farihin, Suteja, Muslihudin, Aris, A. A. Haqq, and W. Winarso, "A skill application model to improve teacher competence and professionalism," *International Journal of Educational Methodology*, vol. 8, no. 2, pp. 331–346, May 2022, doi: 10.12973/ijem.8.2.331.

[14] D. O. Khimmataliev, K. T. Olmov, R. M. Abdullaeva, B. B. Ergashev, and K. T. Chulponova, "Mechanisms of professional competence development in future teachers based on pedagogical and technical knowledge," *Annals of the Romanian Society for Cell Biology*, vol. 25, no. 2, pp. 2950–2958, 2022.

[15] I. Dubrovina, T. Moskalenko, and O. Zinchenko, "Professional development of future teacher: competency approach," (in Ukrainian), *Cherkasy University Bulletin: Pedagogical Sciences*, no. 2, pp. 111–118, 2020, doi: 10.31651/2524-2660-2020-2-111-118.

[16] Q. Zhou *et al.*, "Teaching competency development," in *Handbook of Teaching Competency Development in Higher Education*, J. Cheng, W. Han, Q. Zhou, and S. Wang, Eds., Singapore: Springer Nature Singapore, 2024, pp. 63–125, doi: 10.1007/978-981-99-6273-0_4.

[17] L. Hanyu, K. Buranaphansak, and N. Prachanant, "The teacher professional development model of vocational colleges in Guangxi Province, People's Republic of China," *Journal of Roi Kaensarn Academi*, vol. 9, no. 12, pp. 1151–1166, 2024.

[18] Z. Berlian and M. Huda, "Reflecting culturally responsive and communicative teaching (CRCT) through partnership commitment," *Education Sciences*, vol. 12, no. 5, p. 295, Apr. 2022, doi: 10.3390/educsci12050295.

[19] C.-W. Liao *et al.*, "Inquiry practice capability and students' learning effectiveness evaluation in strategies of integrating virtual reality into vehicle body electrical system comprehensive maintenance and repair services practice: a case study," *Electronics*, vol. 12, no. 12, p. 2576, Jun. 2023, doi: 10.3390/electronics12122576.

[20] N. N. S. P. Verawati and N. Nisrina, "Reimagining physics education: addressing student engagement, curriculum reform, and technology integration for learning," *International Journal of Ethnoscience and Technology in Education*, vol. 2, no. 1, pp. 158–181, Mar. 2025, doi: 10.33394/ijete.v2i1.14058.

[21] S. Hu, "Study on teaching strategies in secondary school physics under the perspective of core literacy," *International Journal of Education and Humanities*, vol. 12, no. 3, pp. 139–142, Feb. 2024, doi: 10.54097/cfjhad29.

[22] C. Ma and M. L. I. Casihan, "Instruction teaching support system and teaching competency in applied colleges, China," *Pacific International Journal*, vol. 7, no. 6, pp. 320–329, Dec. 2024, doi: 10.55014/pij.v7i6.726.

[23] E. Halfon, "Reconceptualizing quality teaching: insights based on a systematic literature review," *Education Sciences*, vol. 16, no. 1, p. 37, Dec. 2025, doi: 10.3390/educsci16010037.

[24] T. Frågåt, M. V. Bøe, and C. Angell, "Providing professional development for physics teachers through participation in a design-based research project," *Nordic Studies in Science Education*, vol. 18, no. 1, pp. 112–127, Jan. 2022, doi: 10.5617/nordina.8712.

[25] A. M. Adeduyigbe, U. K. Okeke, and S. Ramaila, "Bridging cognitive gaps in physics education: the role of age, motivation, and instructional strategies," *Journal of Research in Environmental and Science Education*, vol. 3, no. 1, pp. 1–7, Jan. 2026, doi: 10.70232/jrese.v3i1.21.

BIOGRAPHIES OF AUTHORS

Ze He obtained a doctoral degree from University of Chinese Academy of Sciences in China. He is currently working at the School of Physics and Electronic Information Engineering, Jining Normal University. His main research direction is design and reliability evaluation of digital circuits, and reform of physics teaching in middle schools. He can be contacted at email: 307806@jnnu.edu.cn.

Lumeng Chao obtained a master's degree from Inner Mongolia University in China. She is currently working at the Ulanqab Mongolian Middle School. Her main research direction is reform of physics teaching in middle schools. She can be contacted at email: 13488540615@163.com.

Xiaofei Xue obtained a bachelor's degree from Baotou Normal University in China. She is currently working at the Office of Party and Government Affairs, Jining Normal University. Her main research direction is reform of physics teaching in middle schools. She can be contacted at email: jnnuphysics@163.com; XiaofeiXue3@outlook.com.