US-China Education Review A, August 2026, Vol. 16, No. 8, 580-585
doi: 10.17265/2161-623X/2026.08.004

A Learning-Support Approach to University Physics Education

ZHAO Xinli
University of Shanghai for Science and Technology, Shanghai, China

University physics education often faces low student engagement, superficial homework completion, and unsatisfactory learning outcomes, even when attendance, assignments, online learning, and examinations are included in course management. Based on classroom practice, this paper analyzes the limitations of procedural control and proposes a learning-support approach integrating pre-class diagnosis, question-chain teaching, peer interaction, reflective homework, and formative assessment. The study argues that effective physics education should move beyond task completion and create structured opportunities for conceptual understanding, active reasoning, and self-regulated learning.

Keywords: university physics education, student engagement, learning support, formative assessment, teaching reform

Introduction

University physics is a foundational course in undergraduate science and engineering education. It not only introduces students to essential concepts in mechanics, electromagnetism, thermodynamics, optics, and modern physics, but also cultivates scientific reasoning, mathematical modeling, and problem-solving abilities. However, in actual teaching practice, university physics is often perceived by students as abstract, difficult, and weakly connected with their immediate professional interests. As a result, many students show low classroom participation, limited after-class review, superficial homework completion, and insufficient preparation for examinations.

In many universities, process-based course management has been adopted to improve learning outcomes. Attendance, homework, online learning records, mid-term tests, and final examinations are commonly used to monitor students' learning process. These measures are necessary because they help maintain basic learning order and provide evidence for course assessment. Nevertheless, teaching practice shows that procedural requirements do not automatically lead to deep learning. Some students attend class without active thinking, complete homework by imitating standard solutions, or finish online tasks without genuine understanding. The gap between task completion and conceptual mastery has become a central challenge in university physics teaching.

This problem is closely related to changes in students' learning habits. Contemporary undergraduates are used to fast information access, fragmented reading, and immediate feedback. In contrast, physics learning requires sustained attention, step-by-step reasoning, conceptual comparison, and repeated practice. When

Acknowledgement: This research is supported by "Shanghai University Young Teacher Training Program" by Shanghai Municipal Education Commission in 2024 (No. 23048).

ZHAO Xinli, Ph.D., Lecturer, School of Physics, Faculty of Basic Sciences, University of Shanghai for Science and Technology, Shanghai, China.

students lack self-regulated learning strategies, they may quickly fall into a negative cycle: They cannot follow classroom explanations, become less willing to engage, and gradually lose confidence in the course. Therefore, the difficulty of university physics should not be understood only as a problem of content difficulty, but also as a problem of learning engagement and instructional support, since student engagement involves behavioral, cognitive, and emotional dimensions of learning (Fredricks, Blumenfeld, & Paris, 2004).

This paper argues that university physics teaching should move from procedural control to learning support, which is consistent with the view that effective teaching should focus on what students actually do in the learning process rather than on what teachers merely present (Biggs, 1999). Instead of merely asking whether students have attended class, submitted assignments, or completed online tasks, teachers need to ask whether these activities help students understand concepts, identify misconceptions, improve reasoning, and regulate their learning. Based on classroom practice, this study proposes a teaching approach that integrates pre-class diagnosis, question-chain instruction, peer interaction, reflective homework, and formative assessment. The purpose is to provide a practical framework for improving student engagement and learning quality in university physics education.

Problem Analysis and Theoretical Perspective

The learning difficulties in university physics can be observed in several connected aspects. First, classroom engagement is insufficient. Many students listen passively and rarely respond to questions. When teachers present a derivation, students may lose track after one or two mathematical steps. When teachers ask conceptual questions, students often remain silent, not necessarily because they have no ideas, but because they are uncertain, afraid of making mistakes, or unaccustomed to expressing their reasoning in class.

Second, after-class learning is often shallow. Some students believe that completing assigned homework is equivalent to learning the course. They pay attention to final numerical answers but neglect the physical meaning of quantities, the conditions under which formulas are valid, and the structure of reasoning. For example, when solving problems involving Newton’s second law, students may substitute numbers into formulas without drawing a force diagram. In electromagnetism, they may remember the expression for electric field intensity but fail to distinguish electric field, electric force, potential, and potential energy. In rotational dynamics, they may mechanically imitate examples but lack a clear understanding of torque, moment of inertia, and angular acceleration.

Third, online learning tasks sometimes become a mere formality. Watching videos, completing online quizzes, or submitting screenshots may provide evidence of participation, but such evidence does not necessarily prove conceptual understanding. Students may treat online learning as a task to be finished rather than as a process of preparation and reflection. This is why some students have acceptable process scores but perform poorly in closed-book examinations. The gap between procedural completion and actual understanding is a key problem in current teaching management.

From the perspective of student engagement theory, learning engagement includes behavioral, cognitive, and emotional dimensions (Fredricks et al., 2004). Behavioral engagement refers to attendance, participation, and completion of tasks. Cognitive engagement refers to the effort invested in understanding, connecting, questioning, and applying knowledge. Emotional engagement refers to interest, confidence, sense of value, and belonging. In university physics teaching, process management mainly strengthens behavioral engagement, but weak cognitive and emotional engagement may remain unchanged. If students do not understand why they need to learn physics, do not experience progress, and do not receive timely support, they may gradually develop avoidance behavior.

Cognitive load theory also helps explain students' difficulties. University physics requires students to process physical situations, diagrams, mathematical symbols, concepts, assumptions, and logical relationships at the same time. For novice learners, the intrinsic cognitive load is high. If teaching proceeds too quickly, or if derivations are presented as completed results rather than guided reasoning processes, students' working memory may be overloaded. Once students fail to follow several key steps, the rest of the lecture becomes incomprehensible. Therefore, effective teaching should not simply reduce difficulty, but should organize learning materials, highlight key ideas, and provide scaffolding that helps students manage complexity.

Self-regulated learning theory further suggests that successful students are able to set goals, monitor understanding, choose strategies, and adjust learning behaviors. Many first-year or second-year engineering students have not fully developed these abilities. They may rely on teachers' arrangements and lack the habit of previewing, summarizing, correcting errors, and planning review. In such cases, teachers need to design tasks that guide students to monitor their own learning rather than merely submit finished answers.

Finally, formative assessment theory indicates that assessment should not only judge learning results but also support learning improvement through timely feedback and students' self-regulated learning (Nicol & Macfarlane-Dick, 2006). If attendance, homework, and online learning are counted only as scores, their educational value is limited. If these tasks are used to diagnose misunderstanding, provide feedback, and promote reflection, they can become meaningful parts of learning. Thus, the reform of university physics teaching should move from "Did students complete the task?" to "What did students understand, misunderstand, and improve through the task?"

Teaching Redesign: From Procedural Management to Learning Support

The purpose of the teaching redesign is to transform routine course requirements into meaningful learning activities. Attendance, homework, online learning, and examinations should not function merely as administrative records; they should provide evidence of students' understanding, difficulties, and progress. The redesign therefore follows a sequence of pre-class diagnosis, in-class reasoning, after-class reflection, and formative feedback, helping students move from passive task completion to active conceptual construction.

Pre-class preparation is redesigned as a diagnostic activity. Instead of asking students only to watch videos or preview textbook content, the teacher provides a short task sheet before each key topic. It includes basic conceptual questions, connection questions, and one open question about confusion. For example, before learning electric field intensity, students may be asked to explain its definition, distinguish electric field from electric force, and state the applicable conditions of the point-charge field formula. These tasks reveal misconceptions and help the teacher make classroom instruction more targeted.

In classroom teaching, the main strategy is question-chain instruction, which aims to create interactive engagement rather than passive reception in introductory physics learning (Hake, 1998). Instead of presenting definitions, formulas, and derivations as fixed conclusions, the teacher organizes the lesson around logically connected questions. These questions guide students from physical situations to abstract concepts, from qualitative judgment to quantitative expression, and from formula use to condition analysis. For instance, in teaching Newton's second law, the teacher may begin with whether force maintains motion or changes motion, and then guide students to discuss acceleration, resultant force, mass, coordinate decomposition, and applicable conditions.

Peer interaction is introduced at key conceptual points, following the idea that students can improve conceptual understanding through individual thinking, peer discussion, and teacher feedback (Crouch & Mazur, 2001). Short conceptual questions are used to expose common misunderstandings, such as whether zero velocity necessarily means zero acceleration or whether zero net work implies that every force does zero work. Students first think independently, then discuss briefly with classmates, and finally respond to the teacher. Used selectively, this strategy can improve attention and reveal learning difficulties without occupying excessive class time.

After class, homework is redesigned to emphasize reasoning and reflection. Traditional homework often focuses on correct answers and standard procedures, which may encourage imitation without understanding. Therefore, selected problems require students to explain the physical model, the reason for choosing a method, the meaning of the result, and the source of any error. For typical mistakes, students submit an error-correction note including the original attempt, the incorrect step, the corrected solution, and the concept involved.

Formative assessment is used throughout the course to connect teaching activities with learning improvement, because feedback is most effective when it helps students recognize the gap between current performance and expected learning goals (Nicol & Macfarlane-Dick, 2006). Attendance can be combined with brief in-class responses; online learning can be linked with diagnostic questions; homework can include reflective explanations; quizzes can test both calculation and conceptual discrimination. Through this redesign, procedural management is not abandoned, but reoriented toward learning support.

Action Study and Teaching Observations

The teaching redesign was implemented in a regular university physics course for engineering students over one teaching cycle. The study adopted an action research approach. The instructor identified problems in routine teaching, introduced targeted interventions, observed classroom responses, collected learning artifacts, and adjusted subsequent teaching. The data sources included classroom observation notes, pre-class task sheets, homework submissions, error correction notes, short quizzes, and informal student feedback. The purpose was not to establish a strict causal experiment, but to examine whether a learning-support-oriented model could address common problems in ordinary teaching conditions.

At the beginning of the course, classroom silence was prominent. When the teacher asked open questions, only a few students responded. Many students waited for the teacher to present formulas and examples directly. Pre-class preparation was also uneven. Some students completed online tasks but could not explain basic concepts in their own words. Homework submissions showed a similar pattern: Solutions were often neat, but some students were unable to reproduce the reasoning in quizzes.

After the introduction of pre-class diagnostic sheets, the teacher obtained clearer information about students' difficulties. For example, before learning work and energy, many students wrote that they could calculate work by using formulas but did not understand the meaning of conservative force. Before learning electric potential, many students confused potential, potential energy, and voltage. These responses helped the teacher adjust the starting point of classroom explanation. Instead of assuming that students had completed preparation successfully, the teacher began with the most frequent misunderstandings and used them as teaching resources.

In-class question chains gradually increased visible participation. At first, students were hesitant, especially when asked to explain reasons rather than choose answers. However, when questions were designed as low-threshold but conceptually meaningful prompts, more students began to respond. Peer discussion was particularly useful. Students who rarely spoke to the teacher were willing to discuss with classmates for one or two minutes.

In several lessons, the distribution of answers changed after discussion, indicating that students were not only copying choices but reconsidering their reasoning.

Reflective homework also produced observable changes. In the early stage, some students wrote very brief reflections such as “I used the wrong formula”. After the teacher provided examples of high-quality error correction, students’ explanations became more specific. A better reflection might state: “I treated the acceleration as constant, but in this problem the force depends on displacement, so the work-energy theorem is more appropriate than the kinematic formula”. Such statements show that students began to pay attention to model selection and applicable conditions. Although not all students reached this level, the quality of homework became more informative than before.

Short quizzes revealed that conceptual questions remained difficult for many students, but the frequency of blank answers decreased. Students were more willing to attempt explanations. Some students reported that question chains helped them know “where the formula comes from”, while error correction helped them identify repeated mistakes. A few students still preferred direct solution templates, which suggests that the reform cannot immediately change all learning habits. Nevertheless, the teaching process became more transparent: The teacher could identify learning obstacles earlier, and students had more opportunities to recognize their own problems before the final examination.

The action study also exposed constraints. University physics has limited class hours and broad content coverage. If too much time is devoted to discussion, the teaching schedule may be affected. Therefore, classroom interaction must be carefully selected. Not every concept requires discussion; the most valuable moments are those involving common misconceptions, model construction, or transfer of knowledge. In addition, reflective homework increases the teacher’s workload. A practical solution is to evaluate selected problems in detail, use sampling feedback, and share common errors with the whole class.

Overall, the implementation suggests that process management becomes more effective when each process element is connected to learning evidence. Attendance matters when students are required to think in class. Online learning matters when it produces questions. Homework matters when it reveals reasoning. Assessment matters when it provides feedback for adjustment. The essential change is not the addition of more tasks, but the redefinition of existing tasks.

Discussion

The findings of this teaching practice are consistent with previous research on active learning and physics education, which has shown that interactive engagement and peer instruction can improve students’ conceptual understanding in introductory physics courses (Hake, 1998; Crouch & Mazur, 2001). Hake’s large-scale study showed that interactive engagement methods can produce stronger learning gains than traditional instruction in introductory physics. Crouch and Mazur also demonstrated the value of peer instruction in improving conceptual understanding. These studies suggest that physics learning requires students to actively process ideas rather than passively receive explanations. The present study supports this view in the context of an ordinary engineering university classroom.

At the same time, the study emphasizes that active learning should not be understood as excessive classroom activity. For university physics, the quality of thinking is more important than the appearance of liveliness. A well-designed conceptual question, a carefully sequenced derivation, or a meaningful error correction task may be more effective than superficial group discussion. Teaching reform should therefore respect the disciplinary characteristics of physics. The goal is to help students experience modeling, reasoning, calculation, interpretation, and reflection.

The study also suggests that early-career instructors need to shift their professional identity. A beginning teacher often focuses on explaining content clearly and completing the syllabus. These are necessary abilities, but they are not sufficient. The instructor must also become a designer of learning tasks, an observer of student thinking, and a provider of timely feedback. Good teaching is not only the performance of knowledge but the organization of learning conditions.

Finally, the limitations of the study should be acknowledged. The evidence is mainly based on classroom practice and teaching records, and the implementation period was limited. Future research can use more systematic instruments, such as validated engagement questionnaires, concept inventories, and comparative analysis across different classes. Longitudinal tracking may also examine whether improved engagement in university physics contributes to later professional course learning.

Conclusion

University physics teaching in engineering universities faces a persistent challenge: Many students complete required procedures but do not achieve deep understanding. The problem cannot be solved by stricter attendance, more homework, or heavier examinations alone. The key is to transform procedural control into learning support. This paper proposed and examined a teaching model based on pre-class diagnosis, question-chain instruction, peer interaction, reflective homework, and formative assessment.

The practice shows that when students are guided to express confusion, participate in reasoning, correct mistakes, and monitor their own learning, their engagement can be improved. For instructors, especially early-career teachers, meaningful reform does not necessarily require radical restructuring. It can begin with small changes in ordinary lessons: one diagnostic question before class, one conceptual discussion during class, one reflective correction after class, and one piece of feedback that helps students move forward. In this sense, the improvement of university physics education depends not only on curriculum design, but also on the teacher’s continuous attention to how students actually learn.

References

Biggs, J. (1999). What the student does: Teaching for enhanced learning. *Higher Education Research & Development, 18*(1), 57-75.

Crouch, C. H., & Mazur, E. (2001). Peer instruction: Ten years of experience and results. *American Journal of Physics, 69*(9), 970-977.

Fredricks, J. A., Blumenfeld, P. C., & Paris, A. H. (2004). School engagement: Potential of the concept, state of the evidence. *Review of Educational Research, 74*(1), 59-109.

Hake, R. R. (1998). Interactive-engagement versus traditional methods: A six-thousand-student survey of mechanics test data for introductory physics courses. *American Journal of Physics, 66*(1), 64-74.

Nicol, D. J., & Macfarlane-Dick, D. (2006). Formative assessment and self-regulated learning: A model and seven principles of good feedback practice. *Studies in Higher Education, 31*(2), 199-218.