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Original Paper

Research on the Influence of Problem-Based Learning on Classroom Attention of Mechanical Engineering Students in Secondary Vocational Schools

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Abstract

This paper takes the Problem-Based Learning (PBL) approach as an entry point to explore its effectiveness in enhancing classroom attention among secondary vocational school students majoring in mechanical engineering. By defining the core connotation of PBL and analyzing its suitability and practical implementation pathways in light of the characteristics of vocational students and the current state of mechanical engineering education—covering teaching preparation, implementation, and evaluation—this study addresses the challenges posed by traditional instructional methods. Given that vocational students tend to exhibit strong concrete thinking but have low receptivity to abstract knowledge, and considering that mechanical engineering content often involves complex principles and terminology, traditional lecture-based teaching easily leads to attention dispersion. Therefore, this study transforms course content into problem chains and incorporates true/false logical judgment sub-questions into classroom teaching. This approach aims to drive sustained student engagement through progressively structured tasks, stimulate learning enthusiasm, and improve classroom attention, self-directed learning ability, and teamwork skills.

Keywords

Problem-Based Learning, Secondary Vocational Education, Mechanical Engineering, Teaching Method, Classroom Attention

1. Introduction

During the 2025 National Two Sessions, vocational education emerged as one of the key focus areas. Minister of Education Huai Jinpeng pointed out: "70% of talent in China's modern manufacturing industry comes from vocational education." Vocational education holds a core position in the modern industrial system, playing an irreplaceable role, particularly in cultivating high-skilled talent required by modern manufacturing. It has become a main platform for nurturing master craftsmen and high-skilled personnel, injecting continuous momentum into industrial upgrading (Ou & Lin, 2025).

With the progress of the times and the elevated status of vocational education, the requirements for talent cultivation in secondary vocational education have increasingly demanding. Many schools are actively developing teaching resources and pedagogical reforms, with various teaching methods emerging continuously. The integration of technological tools has further become a powerful aid in teaching. However, in actual teaching practices of secondary vocational education, students often exhibit obvious issues such as distraction and low classroom participation. Classroom attention is a crucial foundation for students' learning, and how to boost secondary vocational students' classroom focus to enhance learning outcomes is one of the hot topics in current vocational education. Although attempts have been made to optimize teaching methods and adjust curriculum designs, the effectiveness of these attempts still needs to be improved (Zhuo, Ying, & Zhao, 2025). The reason lies in the generally low level of interest among secondary vocational students in theoretical learning, coupled with the fact that their mechanical engineering courses—in particular—contain a large number of abstract concepts and complex professional terminology. The traditional teaching model of "teachers lecturing and students listening" hardly matches their learning characteristics.

Among the many explorations into teaching methods, Problem-Based Learning (PBL)—a widely recognized and effective teaching method internationally—boasts a core philosophy that aligns closely with enhancing students' classroom participation and focus. It starts with real or simulated problem scenarios, drives students to actively explore and collaboratively solve problems, and gives students "ownership" of the problem-solving process. By leveraging teachers' exploratory guidance, PBL effectively fosters students' intrinsic motivation and sustains their engagement in class. This provides a promising new approach to addressing classroom inattention. Therefore, PBL is worthy of in-depth exploration and practice for improving the teaching effectiveness of secondary vocational education, and particularly in mechanical engineering classrooms.

2. Overview of Problem-Based Learning

2.1 Core Connotation of Problem-Based Learning

PBL was first introduced in 1969 by Dr. Howard Barrows—an American professor of neurology—at McMaster University's Medical School in Canada (Barrows, 1996). As a problem-oriented teaching method rooted in constructivist theory, it emphasizes solving practical problems in authentic contexts and upholds the practical and social nature of "learning by doing." PBL is a student-centered approach that focuses on designing authentic tasks and situating learning within meaningful, complex, and discipline-specific problem scenarios. In this method, students are required to solve problems through independent inquiry and group collaboration. Through this process, they actively explore the disciplinary knowledge embedded in the problems, while developing their abilities in self-directed learning, analytical thinking, and problem-solving (Liu & Yin, 2025).

2.2 Analysis of "Problem"

The "problem" in Problem-Based Learning is not merely a question; it differs fundamentally from conventional classroom questions. First, in terms of functional roles: The "problem" in PBL serves as the driving force behind the entire teaching process, whereas classroom "questions" function as instructional aids. These questions help teachers timely assess students' grasp of knowledge to adjust teaching strategies dynamically. Second, in terms of student roles: Within PBL, students act as active problem-solvers who must demonstrate a high degree of autonomy. In contrast, students responding to traditional classroom questions are primarily passive responders, answering according to the teacher's predetermined line of inquiry with significantly less autonomy. Finally, in terms of inherent nature: PBL problems are typically open-ended, requiring students to integrate interdisciplinary knowledge and skills for resolution. Traditional classroom questions, whether closed or open, tend to focus narrowly on the understanding or application of discrete knowledge points, making them relatively specific and fragmented. This three-dimensional distinction highlights why PBL's problem design—rooted in authentic, complex scenarios—better aligns with cultivating higher-order thinking skills compared to conventional questioning methods.

2.3 Problem-Based Learning and Secondary Vocational Mechanical Engineering Teaching

In the teaching of mechanical majors in secondary vocational education, the curriculum content often contains a large number of professional terms and complex knowledge points. It covers a wide range of fields, is relatively abstract, and difficult to understand and memorize, so secondary vocational students face certain difficulties in mastering it. At present, an attempt is made to apply Problem-Based Learning (PBL) to transform the curriculum content into the form of a problem chain and present it in classroom teaching. By designing interesting, real and meaningful scenarios and putting forward a series of questions, students' curiosity and desire to explore are aroused, their enthusiasm for learning is stimulated, and their classroom attention is improved. The purpose of this practice is to enhance teaching effectiveness and promote the development of students' abilities.

This paper integrates curriculum knowledge into practical problems through scenario-based question design, in-group cooperation to solve problems, inter-group communication to display results, teachers' summary and answering of questions, and joint discussion between teachers and students, so as to improve students' classroom attention and train their ability to actively construct knowledge. Among them, the design of specific questions in the problem chain is adjusted accordingly based on teaching objectives and learners' characteristics, and these two factors complement each other and are inseparable. In short, teaching objectives are the basis for the design of scenario-based questions, while PBL is a means to achieve teaching objectives. In the classroom teaching of mechanical majors in secondary vocational schools, on the one hand, teachers need to design questions around teaching objectives and cultivate students' comprehensive abilities through solving problems; on the other hand, teachers need to make full use of PBL to achieve the teaching objectives.

Taking the content of Principle and Application of Gear Transmission as an example, the knowledge objective of this course is to master the types and characteristics of gears as well as the calculation formula of transmission ratio. In the traditional teaching method, teachers explain the classification of gears, and students can only memorize the knowledge points passively. This process is relatively boring and results in low learning efficiency. In contrast, PBL designs a targeted problem chain. To guide students to think about the function of gears from the macro perspective of mechanical transmission, Core Question 1 is set: "What role does a gear play in mechanical transmission?" This enables students to form a preliminary comprehensive understanding of the function of gears in the entire mechanical system and build a cognitive framework for the in-depth learning of gear-related knowledge later. At the same time, considering that secondary vocational students have weak abstract thinking ability, directly instilling formulas will lead to poor results and affect their subsequent application of the formulas. Therefore,Core Question 2 is set in the problem chain: "Try to derive the formula for gear transmission ratio". This guides students to understand the essence of the formula in the process of exploring and deriving it, which conforms to their cognitive law from concrete to abstract.

Based on the above, sub-questions corresponding to each core question are further put forward, such as "What are the advantages and disadvantages of gear transmission?" and "What is the relationship between the number of teeth (z) and the rotational speed (n) of the driving gear and the driven gear?" These sub-questions are progressive and help deepen students' understanding of each knowledge point. At the same time, through yes-no logical judgment, other preset questions assist in solving the sub-questions. Finally, students discuss in groups to answer the above questions, which serves as a criterion to judge whether the teaching objectives have been achieved.

3. Implementation of Problem-Based Learning in Secondary Vocational Mechanical Engineering Classrooms

3.1 Pre-class Preparation

To effectively activate students' prior knowledge, reduce their sense of unfamiliarity with new knowledge in class, and lay a foundation for problem-oriented classroom inquiry, teachers use pre-class quizzes to assess students' mastery of "mechanical transmission" and predict potential learning difficulties. Based on the principles of "student-centeredness" and "differentiated instruction", hierarchical tasks are designed in advance: all students are required to complete the basic-level questions, while the challenge-level questions are optional.

Students earnestly complete the pre-class preview tasks, which include the following basic-level questions:

① "Take photos of or draw simple diagrams of gears in daily life". This task aims to guide students to observe real gears in daily life in advance, accumulate perceptual experience and intuitive impressions, which is in line with the characteristics of secondary vocational students' concrete thinking, and establish a connection between classroom learning and life experience. When students enter the classroom with "their own discoveries", they form an attention anchor: "What type of gear did I take a photo of?" This prevents their attention from wandering due to unfamiliarity with knowledge at the beginning of the class. When the classroom content is related to "the gear they photographed", they will more proactively think about "whether my discovery is correct", thereby naturally concentrating their attention.

② "Consult textbooks or online resources to fill in Table 1 below: 'Characteristics of Different Gear Types'". This guides students to gain a preliminary understanding of gear classification, reducing the time spent on teacher-centered knowledge indoctrination in class. During the class, students' cognitive understanding is strengthened by comparing their pre-class preview results with physical gear models.

The challenge-level question is: "Explore the relationship between the number of gear teeth and rotational speed". This question stimulates students with strong curiosity to think in advance, laying a foundation for the subsequent derivation of the calculation formula for gear transmission ratio.

Table 1. Characteristics of Gear Transmission Types

Gear Type	Structural Characteristics Common Application Scenarios	Structural Characteristics Common Application Scenarios
Spur Gear		
Bevel Gear		

Refine the core problem chain, design sub-questions and follow-up guidance, ensure a close connection between pre-class tasks and classroom design, and predict difficulties students may encounter in "gear type selection" and "transmission ratio calculation."

Group students based on their interests and ability differences, and assign clear roles to each group—including an observer, a recorder, and a reporter—allowing each student to utilize their strengths and participate fully in the learning process. Avoid the problem of some students losing focus during group collaboration. Especially in secondary vocational classrooms, ambiguous division of labor tends to lead to "a few dominating while the majority stand by." Fixed roles make each student aware that "their task is important to the group," thus encouraging them to engage actively.

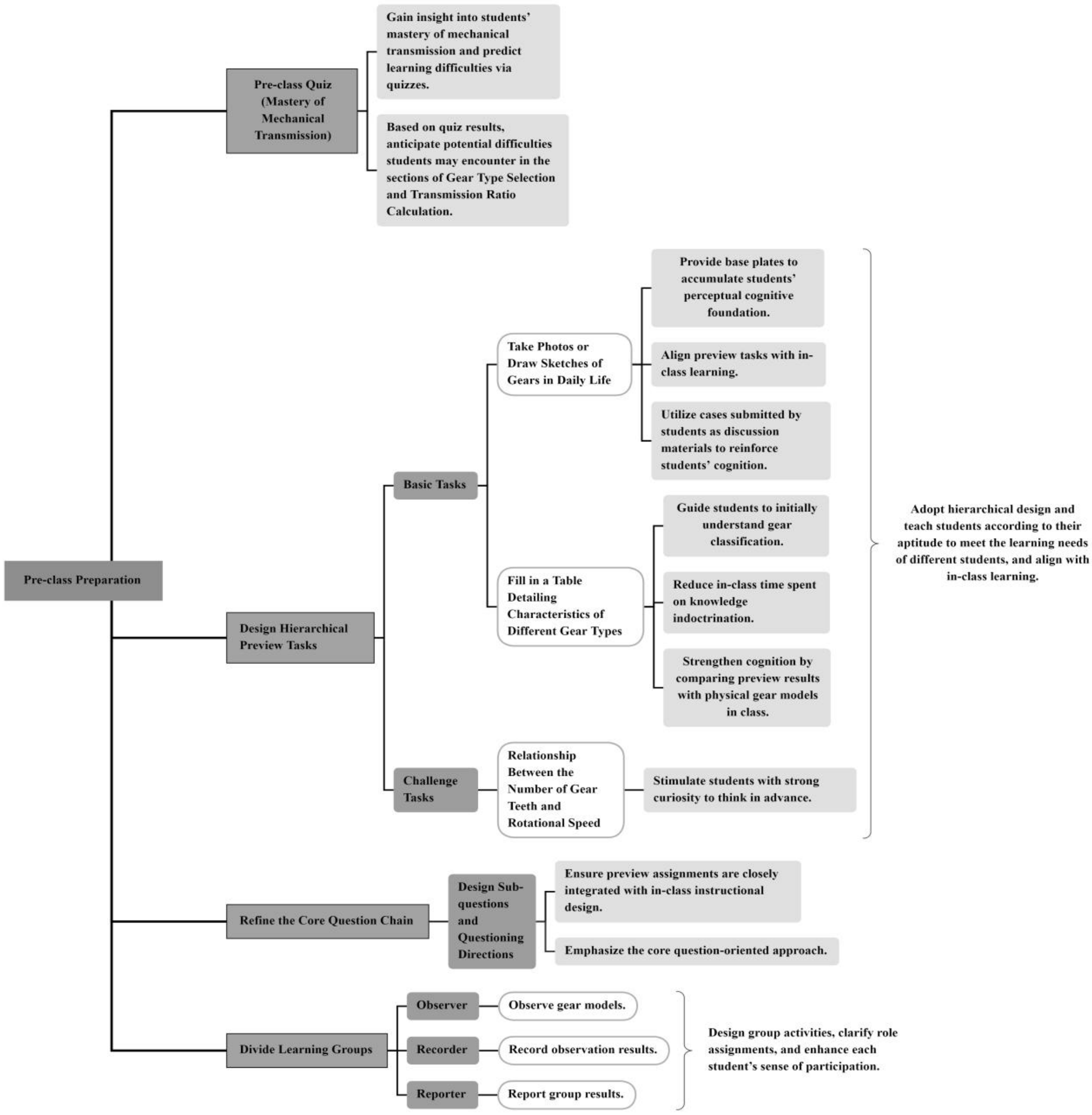

Figure 1. Gear Transmission Teaching Question Chain with Yes-No Logic

3.2 In-class Learning

Through the two core questions designed based on PBL and the chains of sub-questions under their branches, coupled with yes-no logical judgments, various situations and learning difficulties are anticipated. The purpose is to guide students to actively learn and collaboratively explore the knowledge of gear transmission, enhance classroom attention and student engagement, and improve teaching effectiveness.

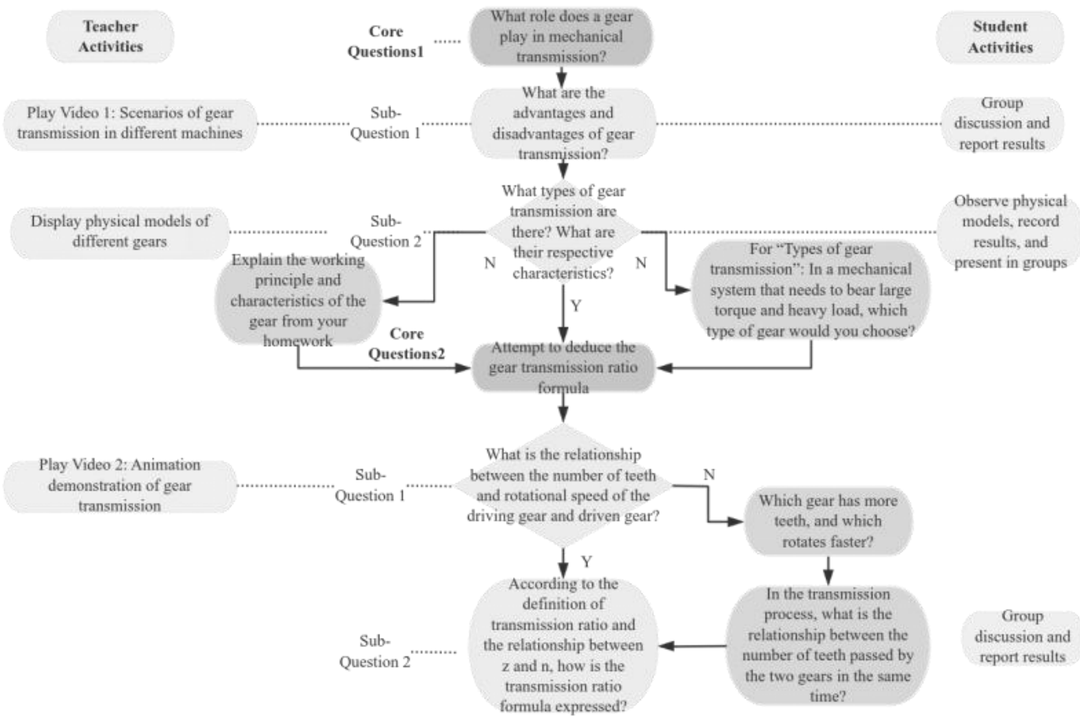

Figure 2. Gear Transmission Teaching Question Chain with Yes - No Logic

Core Question 1: What role does gear transmission play in mechanical transmission?

During the pre-class preview phase, teachers assign the task of "taking photos or drawing simple diagrams of gears in daily life" and use the outputs of this task as materials for creating in-class scenarios. When displaying the gear images from students' assignments in class, teachers can naturally put forward Core Question 1: "What role does gear transmission play in mechanical transmission?" Discussions centered around this core question guide students to further explore the working principles, characteristics, and practical application scenarios of gears, helping them develop a deeper understanding of mechanical transmission systems. Furthermore, showcasing the gear images created by students can stimulate their enthusiasm for participation, allows them to gain a strong sense of accomplishment, and bring more vitality and novel ideas to in-class discussions.

To help students better understand and grasp Core Question 1, the teacher plays Video 1 (which shows gear transmission scenarios in different mechanical systems) and puts forward Sub-question 1: "What are the advantages and disadvantages of gear transmission?" Students are asked to conduct group discussions based on the different gear working scenarios and then report their results. After that, the teacher comments on the reports, summarizes the key points, and writes the characteristics of gear transmission on the blackboard: 1. Relatively high transmission efficiency: The meshing of gears can achieve an efficiency of 0.98; 2. Accurate transmission ratio: For instance, in watches (where gears rotate); 3. Compact structure: It has a small size but can transmit large power; 4. Reliable operation: It has a long service life. The disadvantages of gear transmission are relatively high noise and heavy weight.

In practical teaching, "gear transmission scenarios" — such as the actual operation of gears in some mechanical systems — are relatively abstract. Relying solely on verbal explanations makes it difficult for students to develop a clear understanding. By introducing video teaching resources, the operating status and motion characteristics of gears are presented more intuitively through dynamic images. This helps students analyze "why efficiency is high" and "why noise is loud" in the context of specific scenarios, preventing "advantages and disadvantages" from becoming isolated knowledge points.

Teachers display different physical gear models and put forward Sub-question 2: "What types of gears are there, and what are their respective characteristics?" This guides students to think about the relationship between gear types and application scenarios, and at the same time aligns with Core Question 1, deepening students' comprehensive understanding of gears. Group members observe the physical models, record their findings, and present reports as per their assigned roles, which further strengthens their understanding of gear types.

If students cannot answer accurately, teachers can guide them to first explain the functional principles and characteristics of the gears in their homework, or discuss which type of gear should be selected for a mechanical system that needs to bear large torque and heavy loads. Students are encouraged to consult extracurricular materials and, through group discussions, independently summarize the classification and characteristics of gear types. This approach can stimulate students' interest in learning and cultivate their independent learning ability and teamwork skills (Zhong, 2024). Meanwhile, through the guidance of yes-no logical reasoning, teachers can better grasp students' learning progress and difficulties, thereby adjusting teaching strategies in a targeted manner and improving teaching effectiveness.

2. Core Question 2: Try to derive the formula for gear transmission ratio

Teachers play Video 2—an animation demonstrating gear transmission—and raise Sub-question 1: "What is the relationship between the number of teeth (z) and rotational speed (n) of the driving gear and the driven gear?" If students can derive the relationship based on pre-class challenge tasks and in-class group discussions, teachers directly put forward Sub-question 2: "According to the definition of gear ratio and the relationship between z and n of the two gears, how is the gear ratio formula expressed?"

If students fail to figure out the relationship between the number of teeth and rotational speed of the driving and driven gears, teachers can prompt them by asking: "Which gear has more teeth, and which one rotates faster?" Then, by marking the radii of the two gears with black lines, teachers guide students to observe: "What is the relationship between the number of teeth passed by the driving gear and the driven gear within the same time during gear transmission?" Students then conduct group discussions and present their results. After students understand that the driving and driven gears mesh with each other during transmission—and thus pass the same number of teeth within the same time—the teaching can move on to Sub-question 2.

Let the driving gear have z_1 teeth and a rotational speed of n_1, and the driven gear have z_2 teeth and a rotational speed of n_2. The number of teeth passed by the driving gear per unit time is z_1n_1, and that passed by the driven gear is z_2n_2. Since the two gears pass the same number of teeth within the same time, we have $z_1n_1 = z_2n_2$. Guided by the equation $z_1n_1 = z_2n_2$, students are led to derive the formula for the gear ratio (i). By definition, the gear ratio is the ratio of the rotational speed of the driving gear to that of the driven gear, i.e., $i = n_1/n_2$. Rearranging the equation $z_1n_1 = z_2n_2$ gives $n_1/n_2 = z_2/z_1$, so $i = n_1/n_2 = z_2/z_1$. Teachers further explain the physical meaning of the gear ratio: it not only represents the ratio of the rotational speed of the driving gear to that of the driven gear, but also reflects the inverse proportional relationship between the number of teeth of the two gears—the more teeth a gear has, the slower its rotational speed; the fewer teeth a gear has, the faster its rotational speed.

4. Post-class Consolidation and Feedback

The problem-oriented method covers the entire teaching process in the teaching case studied in this paper, including post-class consolidation. Reasonable question design can deepen students' understanding of the learned knowledge and their application ability, verify the achievement of the course objectives, and provide a valuable basis for subsequent teaching improvement. After class, students are encouraged to sort out key knowledge points—such as the core concepts, types, characteristics, and gear ratio formula of gear transmission—and draw their own mind maps while labeling the questions associated with these points. This helps them form a systematic knowledge system and also reinforces the effectiveness of the problem-oriented method in guiding attention. Through these post-class consolidation tasks, students' understanding of gear transmission knowledge is deepened, and their independent learning ability, analytical ability, and problem-solving ability are cultivated, laying a solid foundation for their future study and work.

5. Conclusion

By transforming the course content into a hierarchical question chain via the problem-oriented method, a "work-anchored, problem-progressive, task-driven" learning path suitable for the characteristics of mechanical major students in secondary vocational schools is constructed. Classes start with students' own works as anchors, reducing the diversion of students' attention from new knowledge at the start of class; then, through the progressive design of sub-questions and guidance of yes-no logical reasoning, students' attention engagement is maintained; finally, task-driven learning is established through role division in groups, enhancing their attention and participation. This implementation adheres to the teaching concept of "student-centered and teacher-led", fully mobilizing students' interest, autonomy, and enthusiasm. It not only helps students better understand classroom knowledge but also cultivates their independent learning ability, application ability, and communication and cooperation skills. In future teaching, we will continue to explore and improve the application of this teaching method, providing stronger support for the holistic development of students.

Fund Project

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