Combining Scientific and Humanistic Approaches in High School Physics Teaching: Taking "Simple Pendulum" as an Example

Jinming Liu[1], Ruobing Fan[2]
[1]*Yuzhong County No.1 Middle School, Lanzhou, Gansu, China*
[2]*Academic affairs office, Lanzhou City University, Lanzhou, Gansu, China*

Abstract: The goal of high school physics teaching under the new college entrance examination system is to cultivate students' "three new" characteristics, and it is also an important way to combine scientific and humanistic approaches. In high school physics teaching, scientific and humanistic approaches complement and promote each other. Only by fully utilizing the characteristics of both scientific and humanistic approaches can the comprehensive development goals of high school physics education be truly achieved. Taking three teaching segments of the "simple pendulum" as examples, this paper explores the importance and realization of combining scientific and humanistic approaches in high school physics teaching. It also proposes specific measures based on theoretical analysis and teaching practice, aiming to achieve an organic combination of scientific and humanistic approaches and improve students' comprehensive qualities.

Keywords: Scientific Approach; Humanistic Approach; Simple Pendulum; High School Physics; Physics Concepts

1. Introduction

In high school physics education, scientific and humanistic approaches can promote each other, jointly constructing a complete knowledge system. Scientific approach refers to the emphasis on fundamental physical theories in high school physics education, including basic principles, laws, and formulas of physics, as well as concepts and principles of fundamental disciplines such as mechanics, electricity, optics, and thermodynamics. Through studying basic physical theories, students can systematically grasp fundamental knowledge of physics and acquire the ability to conduct experiments and theoretical research using scientific methods. Students can also deepen their understanding of physical principles through experiments and calculations, thus cultivating scientific thinking and scientific literacy. Humanistic approach, on the other hand, emphasizes not only the learning of physical knowledge but also the cultivation of students' humanistic qualities [1,2]. The development of physics is intertwined with the progress of human civilization. By exploring the history of physics, students can investigate the origin, development, and impact of the discipline on human society, understand the development of human civilization, and the role and contribution of physics to society. Additionally, some concepts and principles in physics are related to cultural, philosophical, and ethical issues, allowing students to understand significant issues in the humanistic domain through the study of physics, thus enhancing their humanistic literacy. This article takes three teaching segments from Section 4, Chapter 2, of the first elective module in high school physics on "Simple Pendulum" as examples to discuss how to implement a teaching model that combines scientific and humanistic approaches in high school physics teaching to cultivate students' core competencies in physics.

2. Importance of Scientific and Humanistic Approaches in High School Physics Teaching

Scientific approach is the core feature of physics, reflected in the research methods, thinking patterns, and knowledge system of the discipline. High school physics teaching should emphasize scientific approach, enabling students to master scientific methods and thinking patterns, cultivating their scientific spirit and innovation ability.

Humanistic approach focuses on caring for students, emphasizing the cultivation of students' emotions, values, and interpersonal

skills. Incorporating humanistic care into high school physics teaching helps stimulate students' interest and enthusiasm for physics, develop their interpersonal and teamwork skills, and promote their overall development.

The combination of scientific and humanistic approaches aims at achieving core competencies in physics education. Analyzing the oscillation of the simple pendulum from the perspectives of dynamics and kinematics, and deriving the conditions for simple harmonic motion based on the dynamic characteristics of harmonic motion and the restoring force of the pendulum. According to the requirements of the new curriculum standards, the teaching objectives combining scientific and humanistic approaches are listed in Table 1.

Table 1. Core Competencies Objectives of Simple Pendulum

Dimension	Core Competencies Objectives
Physics Concepts	By analyzing the dynamic characteristics of simple pendulum motion, students form the classical physics interaction view and can transform objects and processes in practical problems into simple pendulum models.
Scientific Thinking	Through qualitative and quantitative analysis of the relationship between the pendulum's period and physical quantities, students can infer, analyze data, discover patterns, and form reasonable conclusions. They can use existing physical laws to explain related phenomena, enhancing their scientific thinking ability.
Scientific Inquiry	By designing experiments, developing plans, improving plans, applying technological means to obtain and process information, and drawing conclusions based on evidence, students cultivate their scientific inquiry ability.
Scientific Attitude and Responsibility	Through quantitative research on the pendulum's period and length, students gradually understand the nature of science, realizing that physics is a description and explanation of natural phenomena formed through conscious human exploration. It is a creative work based on observation and experimentation. By applying the learned knowledge to solve practical problems in life and society, students' sense of achievement and responsibility is enhanced.

3. Teaching Strategies Combining Scientific and Humanistic Approaches

3.1 Integration of Teaching Content

Integrate scientific and humanistic approaches into every aspect of high school physics teaching. For example, while teaching fundamental physical theories, intersperse the life stories of scientists and the development history of physics to help students better understand the essence of physical knowledge and its historical context. Emphasize interdisciplinary integration, combining physical knowledge with real-life situations, social issues, and cultural connotations to enhance students' interest in the subject.

Teaching Segment 1: Introduction to a New Lesson. Tell a story: In 1862, 18-year-old Galileo left the seminary to study medicine at the University of Pisa. His mind was filled with marvelous fantasies and endless questions about natural science. One day, at the University of Pisa, he forgot to pray to God and instead focused his eyes on a swaying lamp hanging from the ceiling. He pressed his right hand on his left wrist, silently counting the beats. While others overlooked this phenomenon, Galileo was the first to understand that the time for each swing of the lamp was equal. He then created a model of the simple pendulum and dedicated himself to studying its motion, ultimately contributing the first accurate timekeeping instrument to humanity [3-5].

Reflection 1: Ask students to discuss what they know about Galileo's contributions.

Reflection 2: What methods can be used to explore whether the motion of a simple pendulum is harmonic?

Through active reflection, guide and inspire students to simulate the process of original scientists' exploratory activities, discover new phenomena, and derive the essence and laws of the observed phenomena through association, judgment, reasoning, analysis, synthesis, and induction. Then, apply these laws to real situations. Strive to embody the fundamental methods of physical research, focusing on the process of developing and

applying laws, thereby fostering students' innovative awareness and abilities, and achieving an organic combination of scientific and humanistic approaches.

3.2 Innovation in Teaching Methods

Utilize diverse teaching methods such as heuristic teaching, discussion-based teaching, and project-based teaching. Encourage students to actively participate, collaborate, and explore to cultivate their innovation capabilities and teamwork spirit. Additionally, use multimedia teaching, online resources, and virtual experiments to enrich teaching forms and enhance teaching effectiveness [6-8].

Teaching Segment 2: New Lesson Teaching.

Teacher: Read the content on page 46 of the textbook and answer what a simple pendulum is.

Student: A simple pendulum is an apparatus where the stretch and mass of the string suspending the ball can be ignored, and the length of the string is much greater than the diameter of the ball.

Teacher: Positive evaluation (well answered, timely encouragement) and then ask: Why are there such restrictive requirements for a simple pendulum? (Students ponder, and their answers might deviate from the teacher's expectations). At this point, the teacher should actively correct and guide, concluding that the simple pendulum is an idealized physical model of a real pendulum.

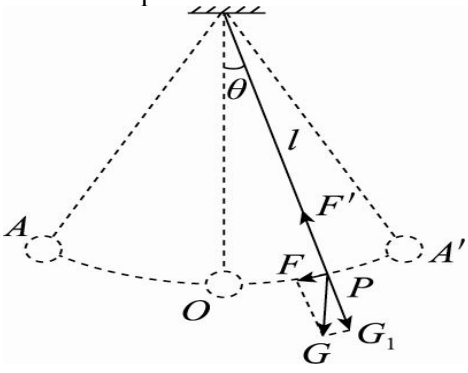

Figure 1. Schematic Diagram of a Simple Pendulum

Teacher: Show a simple pendulum, as shown in Figure 1. When the pendulum bob is at rest at point O, what forces are acting on the bob? What is the relationship between these forces?

Student: The bob is subjected to gravity and the tension of the string, and these two forces are balanced (this answer deviates from the expectation).

Teacher: Conduct an experiment to guide students that the motion of the simple pendulum is also a small-angle circular motion. What force is required for circular motion? Is the net force always zero at the equilibrium position, point O?

Student: (Sudden realization) Although point O is the equilibrium position, the net force is not zero, and circular motion requires centripetal force.

Teacher: When studying the motion of the pendulum bob along the arc, how do you decompose the forces acting on the bob?

$$F = G_1 = G\sin\theta = mg\sin\theta$$

(1) $G_2 = G\cos\theta = mg\cos\theta$ (2)

Student: (Orthogonal decomposition) :

$$F = G_1 = G\sin\theta = mg\sin\theta \quad (3)$$

$$G_2 = G\cos\theta = mg\cos\theta \quad (4)$$

Teacher: Which force provides the centripetal force?

Student: $G_1 = mg\sin\theta$ provides the restoring force for the pendulum bob's motion.

Teacher: Derive that the motion of the simple pendulum is harmonic motion. When the angular displacement is small, $\sin\theta \approx \frac{x}{l}$, and the restoring force $F=mg\sin\theta$, so $F = mg\frac{x}{l}$ (x represents the displacement of the bob from the equilibrium position, and l represents the length of the pendulum). This part should be completed with the students, with some methods explicitly provided.

Student: When the angular displacement θ is small, the direction of the restoring force is opposite to the displacement of the bob from the equilibrium position, and they are proportional in magnitude. Therefore, the simple pendulum undergoes harmonic motion.

Teacher: We know that the graph of harmonic motion is a sine (or cosine) curve. Thus, under small angular displacement, since the simple pendulum undergoes harmonic motion, its vibration graph is also a sine or cosine curve.

High school physics teaching should emphasize the cultivation of students' innovation capabilities, encouraging them to think and explore actively, thereby enhancing their experiment design and operational skills, and fostering their innovative spirit. At the same time, high school physics teaching

should also focus on cultivating students' humanistic qualities, including scientific attitudes, scientific spirit, and humanistic feelings, enabling students to develop a strong sense of social responsibility, citizenship, and cultural literacy [9].

3.3 Reform of Teaching Evaluation

Reform the evaluation methods from single-dimensional knowledge and skills tests to multi-dimensional, multi-level evaluations, including students' scientific inquiry abilities, innovative thinking, teamwork, communication, and other comprehensive qualities. Build a diversified evaluation system to make evaluations more scientific, objective, and fair [10].

Teaching Segment 3: Formulating an experimental report for measuring gravitational acceleration with a simple pendulum, evaluating students' performance in experimental design, operation, analysis, and conclusions to improve their experimental operation skills and experimental spirit.

The teacher presents a comparative diagram of experimental setups as shown in Figure 2, and lets students decide which setup to choose.

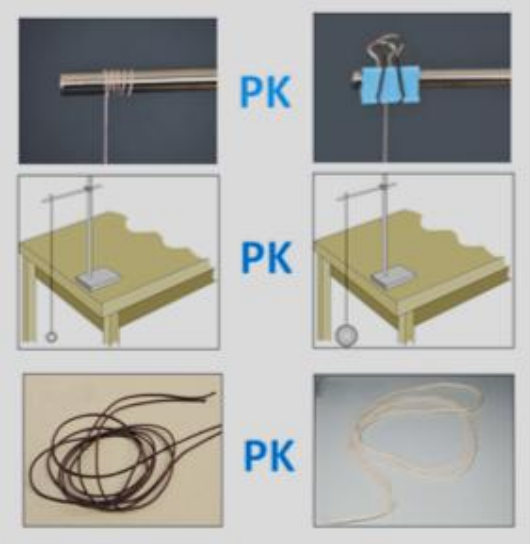

Figure 2. Comparative Diagram of Experimental Setups

Students attempt the experiment, choose a setup, and provide reasons for their choice. Students summarize the requirements for the pendulum bob, string, and suspension point in the experiment [11,12].

High school physics teaching evaluations should emphasize a combination of scientific and humanistic approaches, focusing on assessing students' theoretical knowledge and experimental skills as well as their emotional experiences and humanistic qualities.

3.4 Optimization of Teacher-student Interaction

Teachers should pay attention to individual differences among students, respect their developmental needs, and consider their emotions and values. Create a relaxed, democratic, and equal classroom atmosphere to promote communication and interaction between teachers and students. Students independently arrange time after class to conduct the sand pendulum experiment, as shown in Figure 3, to perceive the simple pendulum as harmonic motion. Teachers actively organize extracurricular activities such as science and technology innovation competitions, physics popularization lectures, etc., to let students understand the forefront developments and applications of physics, enhancing their scientific literacy and innovation capabilities.

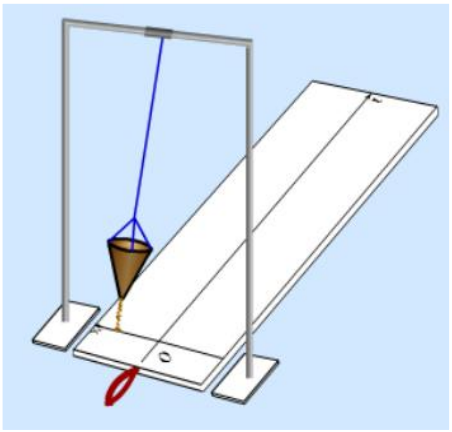

Figure 3. Diagram of the Sand Pendulum Experiment Apparatus

4. Conclusion

Combining scientific and humanistic approaches in high school physics teaching helps improve students' physical literacy, innovative abilities, and humanistic qualities, promoting their overall development. To achieve this goal, it is necessary to focus on teaching content, methods, evaluations, and teacher-student interactions, forming core competency goals that integrate scientific and humanistic approaches.

Using the simple pendulum as an example, this paper discusses the importance and realization of combining scientific and humanistic approaches in high school physics teaching.

Combining theoretical analysis and teaching practice, it proposes a series of specific measures to achieve an organic combination of scientific and humanistic approaches, enhancing students' comprehensive qualities.

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References

[1] Yang Desheng. Analysis of Innovative Strategies for High School Physics Experiment Teaching. Gaokao, 2022(18): 100-102.

[2] Gong Guochun. Study on Methods of High School Physics Experiment Teaching. Shiti and Research, 2020(18): 153-154.

[3] Chen Lishan, Chen Hai. Exploration of Physics Teaching Based on Core Competencies in High School Physics. Basic Education Research, 2016(20): 7-8.

[4] Li Guosheng. Reflections on High School Physics Teaching Based on "Subject Core Competencies". Education Science Forum, 2016(20): 68-71.

[5] Lin Ping. Initial Exploration of the Application of Micro Video Resources in High School Physics Teaching. Nanjing Normal University, 2014.

[6] Fu Zhuwei. Strategies to Promote Deep Learning in High School Physics Teaching. Physics Teacher, 2014, 35(04): 6-7+15.

[7] Gong Xiaofeng. Discussion on Improving and Enhancing Efficiency in High School Physics Experiment Teaching. Mathematical and Physical World (High School Edition), 2022(22): 86-88.

[8] Quan Tiaofen. Cultivating Students' Autonomous Inquiry Ability in High School Physics Experiment Teaching. Guangxi Physics, 2021, 42(04): 63-65.

[9] Jiang Zhichao. Comparative Study and Teaching Practice of DIS Experiments and Traditional Experiments. Guangxi Normal University, 2017.

[10] Li Lijuan. Research on the Explicit Content of Scientific Method Education in High School Physics Experiment Teaching. Capital Normal University, 2013.

[11] Zheng Zejun, Ren Fengzhu. Exploration of High School Physics Teaching Integrating Scientific and Humanistic Approaches: Taking "Space Navigation" as an Example. Physics Teacher, 2021, 42(02): 30-33.

[12] Xia Li. Exploration of Online Teaching in High School Physics Inquiry Courses: Taking "Exploring the Period Formula of a Simple Pendulum" as an Example. Physics Teaching, 2022, 44(11): 28-30.

