ISSN 2706-6827 Vol. 3, Issue 15: 25-32, DOI: 10.25236/IJFS.2021.031503

Difficulty Analysis of Physics Test Questions in Senior High School Entrance Examination Based on Bao Jiansheng's Test Question Difficulty Quantification Tool——Take the 2016-2020 Chengdu High School Entrance Examination as an example

Jie Zhao[a], Lihui Sun[b*]

School of Physics and Optoelectronic Engineering, Yangtze University, Jingzhou, Hubei 434023
[a]Email:zj_77882021@163.com [b]Email:lhsun@yangtzeu.edu.cn
[*]Corresponding Author

Abstract: *The difficulty of test paper is an important index of test paper quality. Most existing research methods can only determine the relative difficulty of a topic, but can not explain the factors that affect the difficulty of the test paper. Therefore, Bao Jiansheng's quantitative model of difficulty is selected as a research tool, and the physics test paper of the senior high school entrance examination in Chengdu, Sichuan Province from 2016 to 2020 is taken as an example to analyze its difficulty.Get the characteristics of physics difficulty changes in recent five years, and on this basis, put forward corresponding suggestions on the test paper life system, in order to provide new ideas for scientific proposition, teachers and students preparing for exams.*

Keywords: *Physics of senior high school entrance examination, Test paper difficulty; Comprehensive difficulty model*

1. Introduction

The senior high school entrance examination shoulders many tasks, such as testing the learning achievements in compulsory education, adjusting daily teaching, and selecting students for further studies. Its baton status is self- evident. Physics is closely related to life, and after the "3+1+2" reform of college entrance examination, it will directly affect students' learning system and their future major choices. It has greatly increased the attention of all sectors of society to physics.

As a direct test tool of physics learning achievements in compulsory education, the difficulty of the test questions not only affects the proposition quality of the test questions, but also restricts the achievement of the test purpose. Therefore, the study of the difficulty of the test questions in the middle school entrance examination not only helps to improve the deficiency of the test paper system, but also enables students to master certain test-taking skills to a certain extent. Make teachers' teaching more targeted. Looking around the difficulty level of the senior high school entrance examination in all provinces of China, Sichuan Province is relatively in the middle, and Chengdu is the vane of education in the whole province. Based on this, the author takes the physics examination questions of the senior high school entrance examination in Chengdu, Sichuan Province from 2016 to 2020 as an example to analyze the difficulty level, aiming at providing useful reference for the proposition, examination questions revision and teachers' teaching of the senior high school entrance examination.

2. Research Contents and Methods

(a) The research object and content

This paper selects the five-year unified physics examination papers in

Chengdu, Sichuan Province from 2016 to 2020, takes 35 questions in each set of papers as the research object, adaptively modifies Bao Jiansheng's test difficulty model, analyzes and compares the

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comprehensive difficulty of the papers in recent five years, and puts forward targeted suggestions for educational peers to share and exchange.

(b) Research methods

As early as 2002, Chinese scholar Bao Jiansheng put forward a tool to quantify the difficulty of test questions, which identified five factors affecting the comprehensive difficulty of mathematics test questions[1], including inquiry, background, operation, reasoning and knowledge content. Further analysis shows that most of these five factors also affect the difficulty of physics test questions.

From this point of view, it is feasible to analyze the difficulty of physics test questions with the help of Bao Jiansheng's test difficulty model [2].

However, the model lacks the quantification of physical modeling ability and the depth of knowledge content examination. At the same time, combined with the characteristics of physics requirements for students in the senior high school entrance examination, the expression of difficulty factors and the division of levels in the original model are modified.Finally, the six-factor difficulty model of "physical situation, depth level, knowledge synthesis, mathematical skills, scientific reasoning and physical modeling" and its assignment description are obtained (Table 1).

Table 1: Difficulty factors and their evaluation criteria

Difficulty factor	Difficulty Subindex	Indicator description	Assignment
Physical situation	No situation	Reproduction of knowledge content in teaching materials.	1
	Life situation	Mainly in the background of life and production.	2
	Scientific situation	Mainly based on scientific and technological achievements.	3
Depth level	Memorize	Extracting relevant knowledge from memory, the definition and direct description of physical phenomena, specific facts and physical principles are the direct application of physical knowledge.	1
	Analysis-understanding	Further reasoning and analysis of knowledge and principles, simple qualitative analysis or supplemented by formula calculation. Such as stress analysis and energy conversion	2
	Application-synthesis	Combine physical laws and principles with specific life, scientific and technological situation or other physical knowledge, and comprehensively analyze and calculate two or more knowledge	3
Knowledge synthesis	Single knowledge	Need a knowledge point to solve the problem	1
	2 knowledge points	Need two knowledge points to solve the problem	2
	Multiple knowledge points	Need three or more knowledge points to solve the problem	3
Math skills	No operation	No mathematical calculations required	1
	Simple calculation	Substituting formulas, unit conversion, general equation solving	2
	Complex	Need to combine image analysis, functions, and	3

	calculation	geometric knowledge for calculations	
Scientific reasoning	No reasoning	No reasoning required	1
	Simple reasoning	Need 1-3 steps of reasoning	2
	Complex reasoning	Need more than 3 steps of reasoning	3
Physical modeling	No modeling required	No need to build a model	1
	Familiar and simple	Familiar situation after processing, such as the model in the textbook, the research object is single, and the physical process analysis is simple	2
	Complex modeling	The surface features of the physical situation are similar to those familiar to the students, but the familiar model needs to be changed, or the combination of multiple models, it is difficult to sort out ideas, such as: dynamic model	3

(C) The test difficulty quantification process

When quantifying the difficulty of the test questions, the first step is to carefully study and sort out the test papers to be studied. Step 2: Refer to Table 1 to assign values to the six influencing factors. Step 3: Calculate the sub-difficulty and overall difficulty of each difficulty factor. The calculation formula is as follows: $d_i=\frac{\sum_j n_{ij}d_{ij}}{n}$, （$\sum_j n_{ij}$=n； i=1, 2, 3, 4, 5, 6； j=1, 2…）.

Here, d_i(i=1,2,3,4,5,6) represent values of the six difficulty factors, d_{ij} represents the assignment value of the i-th difficulty factor at the j-th level (1, 2, 3...); n_{ij} is the number of questions at the j level belonging to the i-th difficulty factor in the test paper. The sum of the number of questions at each level under a given factor should be equal to the total number of questions n. The overall difficulty of the whole test paper is the arithmetic average of the values of d_1 to d_6.

3. Analysis and Results

According to the above model and calculation formula, the questions of five sets of physics papers for senior high school entrance examination in Chengdu from 16 to 20 years are assigned and calculated under six difficulty factors, and the weighted average of each difficulty factor is obtained. The arithmetic average of different difficulty factors in the same year is the comprehensive difficulty of the papers in that year. The research results are as follows.

3.1. Physical Situation

In the difficulty model, physical situation refers to the realistic situation except physical knowledge, which specifically covers three levels: no situation, living situation and scientific situation. According to the calculation, the presentation situation of the number of questions in each level of physical situation in five sets of test papers is obtained, as shown in Figure 1.

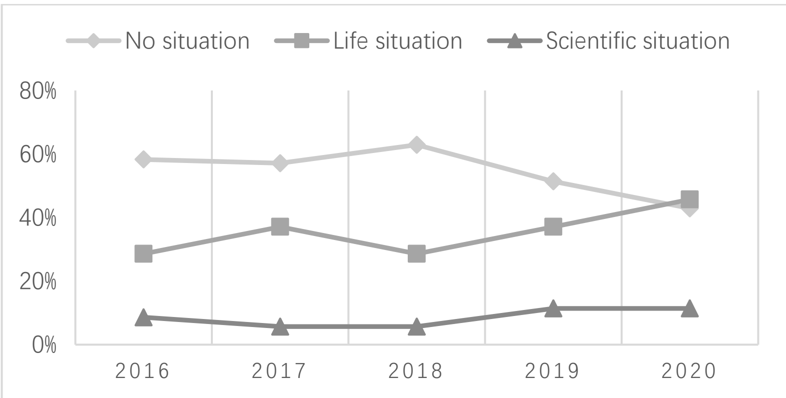

Figure 1: Five-year comparison of physical situational factors

ISSN 2706-6827 Vol. 3, Issue 15: 25-32, DOI: 10.25236/IJFS.2021.031503

It is not difficult to see from the picture that 18 years ago, the unsituated questions in the physics examination questions in Chengdu Senior High School Entrance Examination accounted for more than 60% and the content of scientific situation questions was less than 10%. Since 19, the number of non-contextual questions has begun to decline, while the content of life-contextual questions has gradually increased. In 20 years, it has surpassed non-contextual questions and ranked first, and it is expected to continue to become the mainstream in the future. Although the number of questions based on scientific contexts has also increased slightly, it is still at a low level.

3.2. Depth Level

According to the requirements for students' knowledge and skills in the 2011 version of junior high school physics curriculum standards, the depth level is divided into three levels: memorization, analysis and understanding, and application and synthesis. The statistical results of the number of questions at the corresponding level are shown in Figure 2.

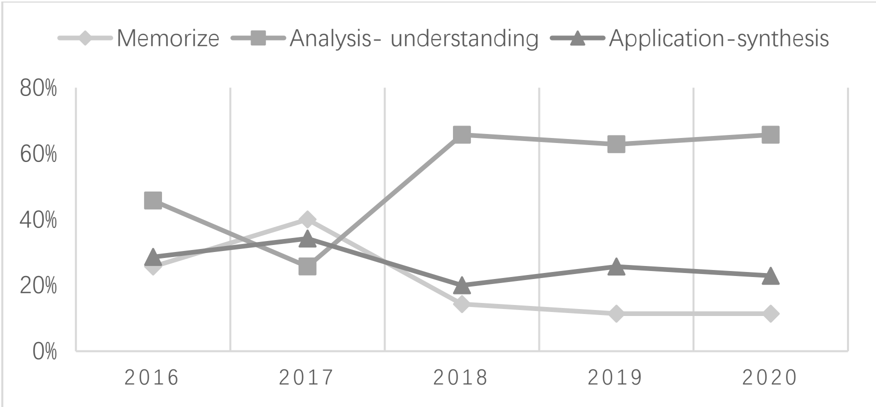

Figure 2: Five-year comparisons of depth level factors

The comprehensive questions of memorization and application were at their peak in the past five years in 2017. At the same time, the content of analytical and comprehension questions was at the lowest point in five years. After 17 years, the requirements for students' analytical and comprehension skills have greatly improved, while simple knowledge The number of questions remembered dropped the most, and subsequently stabilized together with the number of comprehensive application questions. This reflects the change in the ability of educators to students, and to a certain extent, it implies that the difficulty of the high school entrance examination after 18 years has increased. The reason.

3.3. Knowledge Synthesis

The level of comprehensive knowledge of junior high school is divided into single knowledge, 2 knowledge and multiple knowledge. It is because it is extremely rare that four or more knowledge points are required to solve a problem in junior high school. Therefore, these three levels can completely represent the level of junior high school. Requirements for comprehensive knowledge.

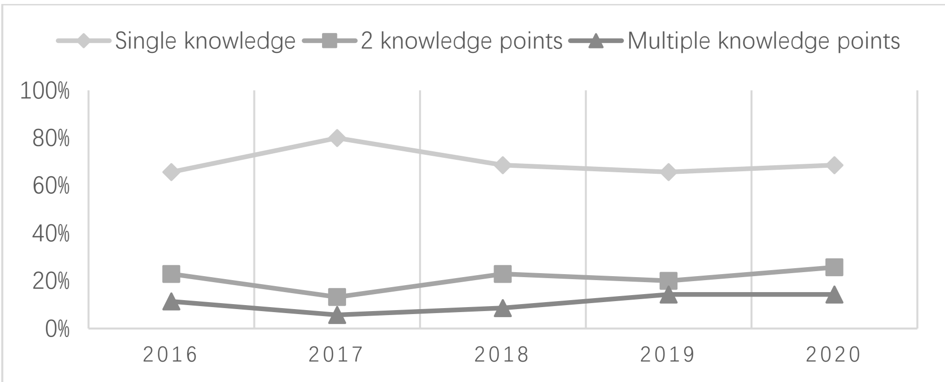

Figure 3: Five-year comparison of comprehensive factors of knowledge

ISSN 2706-6827 Vol. 3, Issue 15: 25-32, DOI: 10.25236/IJFS.2021.031503

At the junior high school stage, the form of one question corresponding to one knowledge point is still the mainstream of the examination, and the total proportion of questions that examine two or more knowledge points at the same time accounts for less than 40%, and this situation has been relatively stable in the past five years. To a certain extent, this is because junior high school physics belongs to the "foundation stage" of physics learning, and most of the cognitive requirements for students in the curriculum standards remain at the level of understanding, cognition, and understanding, and the use of multiple knowledge to solve problems requires comprehensive applications Level. This "6:3:1" difficulty setting structure can not only enhance students' confidence in physics learning, but also play a role in distinguishing and screening.

3.4. Math Skills

When understanding physical concepts and laws to solve physical problems, mathematical knowledge has an instrumental role [3], and mathematical ability is very important to the learning and application of physical knowledge. The requirements of mathematics skills in junior high school physics are often manifested in simple formulas, calculations of equations and complex calculations that need to be combined with image analysis, functions, and geometric knowledge.

It can be seen from Figure 4 that the five-year average of 69% of questions that do not require calculations, simple calculations accounted for 20%-30%, and complex calculations that require image analysis and geometric knowledge, based on the original proportion of less than 10%. Still showing a downward trend year by year. This shows that the focus of junior high school physics learning lies in the understanding and mastery of principles and laws. It is the process of accumulating physics knowledge. Too many complicated calculations not only fail to reflect the real situation of students' physics learning, but also easily breed fears of difficulty and learning-weariness.

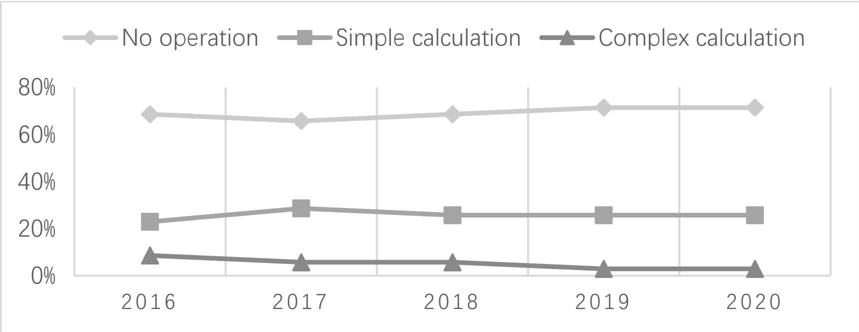

Figure 4: Five-year comparison of mathematical skills factors

3.5. Scientific Reasoning

In recent years, the degree of attention to scientific thinking in the core literacy of physics has been greatly increased, and the ability of scientific reasoning has a significant impact on the development of students' physics learning and thinking. This article divides the thrust level of the physics test questions in the senior high school entrance examination into three levels according to the steps required for reasoning: no reasoning, simple reasoning and complex reasoning. The percentages of questions at each level are shown in Figure 5.

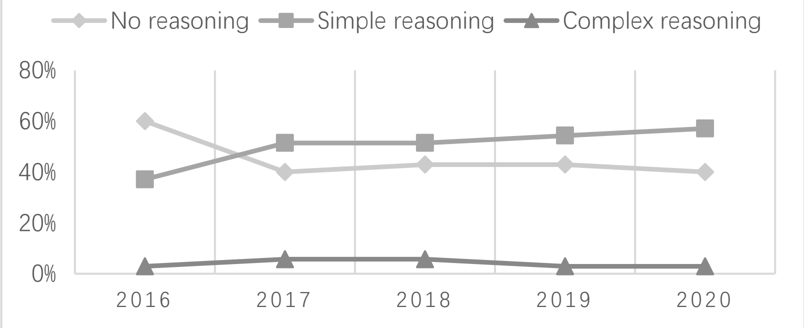

Figure 5: Five-year comparison of scientific reasoning factors

ISSN 2706-6827 Vol. 3, Issue 15: 25-32, DOI: 10.25236/IJFS.2021.031503

Questions that do not require reasoning accounted for more than half of the country before 17 years. With the increasing attention of scientific thinking in recent years, the number of simple reasoning questions has shown an increasing trend, and the number of questions without reasoning has decreased. Among them, complex reasoning is only 17 In 2018, it rose to 5.7%, and remained stable at 2.9% in other years.

3.6. Physical Modeling

The requirements of high school entrance examination physics for modeling ability are mainly manifested as no modeling; simple and familiar, such as common models in textbooks; complex modeling, such as slowly immersing a block on one end of a pulley block in water to judge the force. The performance of these three levels in the test questions is shown in Figure 6.

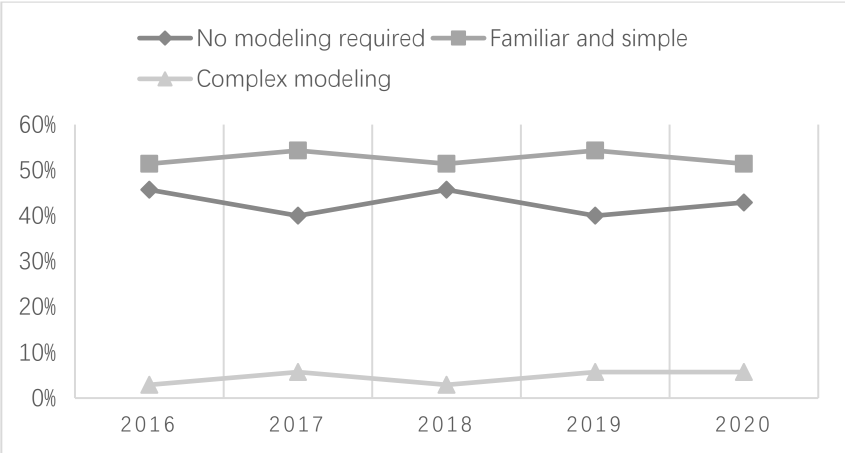

Figure 6: Five-year comparison of physical modeling factors

The examination questions on physical modeling in the middle of 16-20 years are basically stable. There is not much difference between the number of questions that do not require modeling and that need to use familiar models to solve problems. The two occupy 95% of the questions, and they are at the level of complex modeling. There are no more than two questions per year. It can also be seen from the test questions that the complex and comprehensive application of various models often appears in the last multiple-choice questions of Volume B or the final comprehensive calculation questions. This shows that junior high school physics focuses on students mastering the principles of familiar models. Laws and low requirements for complex problem-solving capabilities.

3.7. Overall Difficulty Difference

According to the above statistical results and the difficulty calculation formula, five sets of test papers from 16-20 years are calculated, and the difficulty value and comprehensive difficulty value of each difficulty factor in the corresponding year are obtained. The statistical results are shown in the following table:

Table 2: Comparison of Comprehensive Difficulty in 2016-20

Year / Factor	2016	2017	2018	2019	2020
Physical situation	1.514	1.486	1.371	1.600	1.685
Depth level	2.029	1.943	2.057	2.143	2.114
Knowledge synthesis	1.457	1.257	1.400	1.485	1.542
Math skills	1.400	1.400	1.371	1.314	1.314
Scientific reasoning	1.429	1.629	1.629	1.600	1.628
Physical modeling	1.570	1.657	1.571	1.660	1.629
Comprehensive difficulty	1.567	1.562	1.567	1.643	1.652

In order to more intuitively and clearly show the changes in the difficulty of the various dimensions in the past five years, the overall distribution of [4] and the overall difficulty is used to draw a radar chart of the overall difficulty of the five-year test questions (Figure 7).

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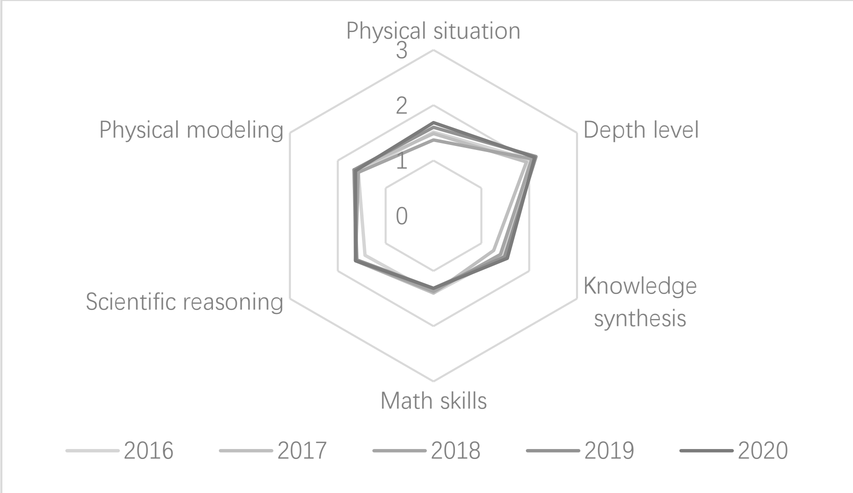

Figure 7: Radar chart of comprehensive difficulty in 2016-20

It can be seen intuitively from Table 2 and the radar chart that the difficulty of the exam questions in Chengdu from 2016 to 2020 has not changed much, but there are also certain differences.

The examination of the six dimensions in each year is relatively stable. Among them, the difficulty of the examination of the physical situation fluctuates the most, and it has increased significantly from 19 to 20. The number of questions in the examination questions is gradually increasing, and the scientific situation has also risen slightly. ; Secondly, the difficulty of the comprehensive dimension of knowledge has also shown an upward trend; the depth level and comprehensive dimension of knowledge have increased significantly in 18-20 years compared with the previous two years, and the dimension of scientific reasoning has remained at a relatively high level since 16 years. , To a certain extent, led to an increase in the overall difficulty level after 18 years.

This also implies that under the background of "burden reduction", students feel that the high school entrance examination is more difficult: Although the absolute difficulty of the test questions has been reduced under the policy guidance, it is presented in a more flexible form, such as using two or more knowledge points. , Transition from memorization and comprehension to understanding and application, from non-contextual problems to life situations as the background, that is, from "biased, difficult, complicated" to "basic, refined and lively". The high school entrance examination still makes most students find it difficult when the content of learning knowledge needs to be streamlined.

4. Reflections and Suggestions

Based on the comprehensive difficulty of the examination papers in the past five years and the analysis of the overall order of the examination papers, the following three suggestions are proposed for reference.

4.1. Incorporate "STSE" Elements

In the past five years, the increase in the difficulty of the physical situation of test questions has been manifested in the increase of questions based on life situations. Among them, the content of questions on the background of social development and environmental protection is not high, and the growth of questions on the background of science and technology is weak, which is not conducive to students' emotional attitudes and values. Formation and cultivation. Therefore, the integration of STSE education composed of science, technology, society, and environment with the physics test questions of the senior high school entrance examination is extremely urgent. Throughout the 2016-2020 examination papers, the content of the examination contains technical (T) and social (S) questions that only increased after 19 years. Among them, the questions that are combined with science (S) and environment (E) have been in the past five years. The total is no more than ten, which is significantly lower than the combination with society and technology. Even so, the total number of questions involving "STSE" each year is only in the single digits. This requires that the proposition experts should comprehensively consider the possibility of integrating the content of the examination with the "STSE" elements when preparing the test questions, such as combining the application of new

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materials under the secondary subject with science and technology, energy and sustainable development and environmental society Combination, energy conversion and technology-society integration, sound-optics and social development, etc. Through the use of exams to promote learning, teachers are encouraged to incorporate "STSE" elements in the physics teaching process, so that students not only learn knowledge, but also cultivate students' sense of social responsibility and mission during the learning process, and form a correct outlook on the person. Worldview.

4.2. Open up new Question Types and Implement Core Literacy

The Chengdu High School Entrance Examination Physics test paper consists of selection, filling in the blanks, drawing, experiment, comprehensive calculation, etc., among which experiments and comprehensive calculation questions that can express scientific thinking and inquiry ability, but also insufficient attention to students' innovative thinking and inquiry ability, and the level is single. Cannot really stimulate students' thinking. Therefore, it is necessary to incorporate open questions focusing on innovation and inquiry into the middle school examination questions, and fully implement the core literacy [5].

For example, it is presented as a small question: (1) Imagination question: Imagine that there is no electricity and magnetism in life, what changes will happen to our daily life? What will happen to the earth if the sun only shines without heating? (2) Applying association questions: Please explain the working principles of straws and liquid thermometers. What other phenomena in life also apply these principles? (3) Design and production questions: Please design the design plan to separate iron filings and sand; please design a security door cat-eye door mirror according to the imaging law of the convex lens.

4.3. Attach Importance to Knowledge Synthesis and Construct a Knowledge Network

In the past five years, although the difficulty of testing the comprehensive application ability of knowledge in Chengdu Senior High School Entrance Examination has increased, the questions that only examine single knowledge still account for more than 65%. The comprehensive situation of similar knowledge is not ideal, which is not conducive to the construction of students' knowledge network. Therefore, the senior high school entrance examination as the vane of junior high school physics education should pay attention to the connection between the knowledge points and the comprehensive ability. For example, when examining the comprehensive application capabilities of changes in the state of matter, resistance and Ohm's law, you can set up this type of inquiry question: the tungsten filament of an incandescent lamp will become thinner after a long time, and the bulb will become black. Why does it become thinner? What happens to the resistance of the bulb after being thinned? Does the brightness of the bulb change? Another example is the sustainable integration of energy into the household electricity module, which not only combines knowledge points, but also cultivates students' awareness of energy conservation in life, so that students truly understand that knowledge comes from life and is applied to life.

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