



Comparative Analysis of High School Physics Textbook “Energy and Sustainable Development”

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Abstract

“Energy and sustainable development” is an important theme in senior secondary physics teaching, which involves the development of human society and environmental protection, and is of great significance to the development of students’ scientific literacy and social responsibility. A comparative study of senior secondary physics textbooks can help us understand the similarities and differences between different textbooks in terms of the writing characteristics, knowledge content, practical activities, etc. of this theme. Therefore, this paper takes “Energy and Sustainable Development” in six editions of textbooks, namely, People’s Education edition, Luke edition, Shanghai Science and Education edition, Guangdong edition, Education Science edition and Shanghai Science and Technology edition, as the object of study, and analyses the strengths and weaknesses of the design of the textbooks of the different editions, to provide certain references to the teaching of physics in high schools and at the same time, enhancing the environmental protection awareness and the sense of sustainable development of the students.

Subject Areas

Senior High School Physics

Keywords

Senior High School Physics, Textbook Comparison, Energy, STSE

1. Introduction

In the General High School Physics Curriculum Standards (2017 Edition, 2020 Revision), the requirements for this section are: 1) Understand ways to utilize

water, wind, solar, and nuclear energy. Preliminary understanding of nuclear fission and nuclear fusion. 2) Know that different forms of energy can be transformed into each other, that the total amount of energy remains constant during the transformation process, and that energy transformations are directional. 3) Understand the classification of renewable and non-renewable energy sources, and recognize the impact of excessive development and use of energy on the environment. 4) Recognize the harm of environmental pollution, understand the importance of coordinated development of science, technology, society, and environment (STSE), and have the consciousness and behavior of environmental protection [1].

Through the interpretation of the new curriculum and textbooks, it is found that the part of “energy and sustainable development” is relatively simple, aiming at cultivating students’ sense of social responsibility and the concept of sustainable development. At present, comparative studies of secondary school physics textbooks based on “energy and sustainable development” mainly include comparative studies on STSE content, studies on the examination of related knowledge in the college entrance examination questions, and studies on the penetration of STSE education concepts in the classroom. However, there are few systematic analyses of the content of “energy and sustainable development”, so this paper will take “energy and sustainable development” as an example, to start the comparison from different angles, hoping to promote teachers to better combine with the learning situation for teaching. The author has selected six versions of high school physics textbooks (Compulsory III), namely, People’s Education edition, Luke edition, Shanghai Science and Education edition, Guangdong edition, Education Science edition and Shanghai Science and Technology edition.

The essay is set up as follows: Part II compares the placement and substance of the chapters on energy and sustainable development in the different textbook editions. Part III examines the taxonomy of energy sources and the law of conservation of energy. The exercises and the STSE section are examined in the fourth and fifth chapters of the textbook, respectively. Finally, conclusions about the textbook comparison are reached.

2. Comparison of Chapter Locations and Logic

2.1. Comparison of Chapter Positions

Contents related to energy and sustainable development are all in compulsory Section 3 in each version of textbooks, but the chapter placement is different. Therefore, this paper compares the chapter introducing energy and sustainable development, as shown in **Table 1**.

As can be seen from **Table 1**, in terms of the chapter headings in which energy and sustainable development are located, the People’s Education edition is electricity energy and the energy conservation law, the title of the Guangdong edition is Electricity and sustainable development of energy, and the title of the chapters in the remaining four versions is energy and sustainable development.

Table 1. Location of chapters of textbook versions.

Textbook version	Location and Chapter Design
People's Education edition	Chapter 12: Electrical Energy The Law of Conservation of Energy §12.4 Energy and sustainable development
Luke edition	Chapter VI. Energy and sustainable development Introduction Development of new energy sources §6.1 The many forms of energy §6.2 Transformation and conservation of energy §6.3 Cherish nature
Shanghai Science and Education edition	Chapter VI. Energy and sustainable development §6.1 Transformation and conservation of energy §6.2 Energy use and environmental pollution §6.3 Energy development and environmental protection § 6.4 Energy conservation, resource protection and sustainable development
Guangdong edition	Chapter V. Electricity and sustainable development of energy sources §5.2 How energy is utilized §5.3 Transformation and conservation of energy §5.4 Energy and Environment
Education science edition	Chapter IV. Energy and sustainable development §4.1 Energy The law of conservation of energy §4.2 Energy §4.3 Environmental protection and sustainable development
Shanghai Science and Technology edition	Chapter XII. Energy and sustainable development §12.1 Energy and its Applications §12.2 Transformation of energy §12.3 Energy and Environment

The People's Education edition has the least knowledge capacity of energy and sustainable development with a total of 4710 characters, the Shanghai Science and Education edition has the most knowledge capacity with a total of 15,123 characters, and the Luke edition, Guangdong edition, Education Science edition, and Shanghai Science and Technology edition have 7414, 8922, 11,321, and 13,078 characters, respectively. In terms of the subsections of the content on energy and sustainable development, the People's Education edition has fewer subsections, occupying only one subsection, with a clear knowledge line and easy for students to understand. The other versions of the textbook divided the content into subsections, with the difficulty of knowledge ranging from shallow to deep, among which, the Shanghai Science and Education edition divided it into four subsections, and the remaining four versions of the textbook divided it into three subsections.

Reviewing the textbooks of the six editions, we found that the "Energy and Sustainable Development" of the People's Education edition, and the Luke and the Guangdong edition are preceded by circuits and their applications, followed by electromagnetic fields. Shanghai Science and Education edition, Education Science edition, Shanghai Science and Technology edition textbook "Energy and

sustainable development” is located in the last chapter of Compulsory Study 3, the front content of the circuit and its application and electromagnetic fields and electromagnetic waves. Six versions of the textbook are the knowledge of the circuit to the front, for the study of energy and sustainable development in the “Energy Conservation Law” part of the content to lay the foundation, for the cognitive laws of students.

2.2. Comparison of the Knowledge Logic

All six versions of the textbook include three parts of knowledge: “Transformation and Conservation of Energy”, “Classification and Utilization of Energy”, and “Energy and Environmental Protection”. The order of presentation is shown in **Table 2**.

Knowledge points are organized from light to deep, reflecting the logic between knowledge [2] [3]. As can be seen from **Table 2**, the textbooks of People’s Education edition, Shanghai Science, and Education Science edition first arrange the transformation and conservation of energy, and then arrange the classification and use of energy, and this arrangement begins with the student’s existing experience, and it is explained to the students in detail through theoretical knowledge of the energy conservation law that, although the total amount of energy does not appear to be infinite [4]. The remaining three versions of the textbook arrange the classification and utilization of energy before the transformation and conservation of energy, weakening the logic between the two parts of knowledge. In the Shanghai Science and Education edition, energy use is included in the environmental protection section, while in the Guangdong edition, energy classification is included in the environmental protection section.

Different versions of secondary physics textbooks have slightly different ways of understanding “energy and sustainable development”, but they all meet the requirements of the curriculum standard from the perspectives of energy conversion and conservation, energy classification and use, and energy and environmental protection. Each version of the textbook has its characteristics, for example, the secondary headings of the Shanghai Science and Technology edition

Table 2. Logical presentation of knowledge of textbook versions.

Textbook version	order of presentation
People’s Education edition	Transformation and conservation of energy - Classification and utilization of energy sources - Energy and the environment
Shanghai Science and Education edition	Transformation and conservation of energy - Classification of energy sources - Energy utilization and the environment
Education science edition	Conservation of energy - Energy quality, classification of energy sources - Energy and environment
Luke, Shanghai Science and Technology edition	Classification and utilization of energy - Conversion and conservation of energy - Energy and environment
Guangdong edition	Utilization of energy - Conversion and conservation of energy - Classification of energy sources and the environment

textbook are provided in the form of questions; The Luke edition and the Education Science edition textbook pay more attention to the investigation of each knowledge point; The People's Education edition, the Shanghai Science and Education edition and the Guangdong edition textbook emphasize more on the connection of knowledge and the systematization of knowledge [5].

3. Comparison of the Preparation of Parts

3.1. Comparison of the "Energy Conservation Law"

3.1.1. Introduction of the "Energy Conservation Law"

When introducing the "Energy Conservation Law", the textbooks of the Education Science edition and the Shanghai Science and Education edition incorporate the scientific history of the discovery of the "Energy Conservation Law", so that students can mobilize their enthusiasm for learning it by mobilizing of the scientists' drilling and research deeds based on the basic knowledge of physics, and cultivate their scientific research spirit and scientific outlook subtly [6]. In the introduction of the "Energy Conservation Law", the Luke and Guangdong editions of the textbook firstly start from the content of the Law of conservation of mechanical energy that students are familiar with and then derive the formula of Ohm's Law for closed circuits, $E = U + Ir$ to obtain $EIt = UIt + I^2rt$, and finally state that the total energy remains unchanged in the process of conversion of electrical energy. This treatment makes it easy for students to understand the physical meaning and scope of application of the "Energy Conservation Law". In contrast, the People's Education edition's introduction weakens the formula's derivation process and only briefly mentions an example of energy conversion in a circuit, while the Shanghai Science and Technology edition's introduction is more uniform and only mentions the law of conservation of mechanical energy.

3.1.2. Description of the "Energy Conservation Law"

The description of the "Energy Conservation Law" differs slightly between textbook editions. In terms of description completeness, the Shanghai Science and Education and Shanghai Science and Technology editions are relatively complete, with the former emphasizing energy transfer from one system (object) to other systems (objects) and the latter indicating energy transfer from one part of an object to another, whereas the other editions only describe energy transfer from one object to another. To ensure that "energy is neither destroyed nor produced" and "the total amount of energy remains unchanged in the process of transformation and transfer", the object of the "Energy Conservation Law" must be "a system that has no energy exchange with its environment". Thus, in terms of the precision of the description, Luke edition is more precise, emphasizing an isolated system, the other editions of the textbook do not mention the preconditions for the application of the "Energy Conservation Law".

3.2. Comparison of "Classification of Energy Sources"

A comparison of the six versions of the textbook reveals that there is no defini-

tion of “energy” in the People’s Education edition and Luke edition, and it is a bit abrupt to categorize energy directly. The other four versions of the textbook first define the concept of “energy”, and then describe the classification of energy and its application, which is in line with students’ cognition.

Regarding the section on “Classification of energy sources”, different textbooks take different approaches to categorization. The People’s Education edition and Shanghai Science and Education edition classify them into renewable and non-renewable energy sources and give common examples. In terms of the comprehensiveness of the classification of energy sources Guangdong and Shanghai Science and Technology editions do a better job. In addition to the common classification of primary energy sources (including renewable and non-renewable energy sources) and secondary energy sources, the Guangdong edition also classifies energy sources into polluting energy sources and clean energy sources according to whether or not the energy sources pollute the environment, while Shanghai Science and Technology edition introduces the classification method according to the source, nature and utilization technology of the energy sources. Other editions of the textbook have less material in the section “Classification of Energy” and only briefly cover it.

4. Comparison of Examples and Exercises

Examples and exercises, as one of the important parts of the textbook, play a role in guiding, understanding and consolidating students’ learning [7]. Therefore, a reasonable presentation of examples and exercises can, to a certain extent, better help students understand and apply their knowledge.

4.1. Comparison of Sample Questions

Among the six editions of the textbook, the Education Science edition and the Shanghai Science and Education edition set the example question of “Energy and sustainable development”, which is not covered in other editions. In terms of the number of example questions, the Shanghai Science and Education edition is more than the Education Science edition. As far as the sample question format is concerned, the Shanghai Science and Education edition uses simple and concise language to describe, and the complete solution is the main; The Education Science edition includes questions, analysis, answers and expansion, and each module is more detailed [8]. The specific comparison is shown in **Table 3**.

The table above illustrates how the example problems in the two versions of the textbook differ significantly from one another. One difference is the variation in the number of sample problems. The first section of the Education Science version contains just one sample problem. The second and fourth parts of the Shanghai Science and Education edition contain two sample problems. The application of the energy conservation law is the main focus of the Education Science edition’s content. The Shanghai Science and Education edition focuses on the effects of energy usage on life and the environment.

Table 3. Comparison of textbook examples.

	Education science edition	Shanghai Science and Education edition
quantities	1 Reasons for stopping a perpetual motion machine and balance position	4 Meaning, causes and hazards of the greenhouse effect Causes and hazards of haze, treatment measures Impact of crude oil price hike on life due to energy crunch Estimation of 100 km fuel consumption of a car and daily household electricity consumption
specification	Question, Analyze, Answer, Expand	Simple and concise language narrative, complete answers, few with analysis

On the other hand, there are differences in the format of example problems. The Education Science edition of the sample problems section, for example, demonstration, presents a clear hierarchy, including questions, analysis, answers and extension of several modules, each module is described in detail, and in the analyzing section, there is strong guidance for students, for example, it seems to be easy to explain in terms of conservation of energy. In the expansion section, the education on the history of the science of perpetual motion machines is permeated, which plays an important role in developing students' scientific literacy [9]. The Shanghai Science and Education edition also focuses on the process of answering questions, but its language is concise and condensed, and it shows more flexibility in the format, for example, the individual sample questions have added the thinking section, which can further disperse students' thinking.

4.2. Comparison of Exercises

Statistics on the exercises of the six versions of the textbook "Energy and Sustainable Development" show that there are significant differences in the number and type of exercises and the examination of student's abilities, as shown in **Table 4**.

As shown in **Table 4**, the Shanghai Science and Education edition and the Shanghai Science and Technology edition have the most exercises, both of which are 24 questions and rich in exercise types, with the Shanghai Science and Technology edition having a relatively single column of exercises, and the names of the section exercises and chapter exercises are all homework and activities. The People's Education edition of the least number, does not involve the corresponding chapter exercises, types only thinking questions and calculation questions, focusing on the simple application of knowledge, more science and technology and production, and life in the background, for example: "Observe the household goods, point out what energy conversion? What is the maximum power generated by the Three Gorges Power Station?" These questions are easier to answer as long as students master the knowledge and think a little.

The Education Science edition of the exercises is arranged as 1 calculation question, 13 reflection questions, and section exercises presented in the form of "self-evaluation". The title with a short description of the language, the difficulty

Table 4. Comparison of exercises by edition.

	People's Education edition	Luke edition	Shanghai Science and Education edition	Guangdong edition	Education science edition	Shanghai Science and Technology edition
quantities	6	16	24	11	14	24
section exercises	Exercises and Applications	practice session	Homework and Activities	practice	self-esteem	Questions and reflections
chapter exercises	not have	End of Chapter Exercises		Exercise 5	Chapter Review Questions	Review and consolidation
typology	Reflection questions, calculation questions	Reflection questions, practice and extension	Reflections, Calculations, Multiple Choice, Practice and Extension	Thinking questions, multiple choice questions, calculation questions, table questions, practice and extension	reflection questions, calculation questions	reflections, Calculations, Practice and Extension

is low, and most of the questions can't mobilize students' thinking at a deeper level, for example: "Do you know what forms of energy are there? On what basis is energy categorized?" Such questions are designed to consolidate and review learning.

The exercises in the Luke edition are set up with a strong openness, mostly presented in the form of inquiry activities and practical investigations, which are conducive to enhancing students' sense of active participation and deepening their understanding of the relationship between science, technology, society and the environment, e.g., "consulting the information to understand the historical prospects of human use of nuclear energy and the challenges it faces, learning about the advantages and disadvantages of different sources of energy for generating electricity through questionnaire surveys, and learning about the perpetual motion machine through the Internet and libraries".

The Guangdong edition has fewer exercises, but the types of questions are more varied, and the examination of student knowledge and ability is more comprehensive. For example, the multiple-choice questions and table questions on energy source categorization adequately examine students' memorization and understanding of basic knowledge. Reflective and calculating questions require students to apply what they have learned to some simple situations, which might help pupils develop their fundamental math and logical thinking skills. Practice and extension questions require students to comprehend and apply relevant knowledge through specific investigations or practices, which helps to build the link between physical knowledge and social reality.

5. Comparison of STSE

STSE stands for Science, Technology, Society, and Environment [10] [11]. Teachers follow STSE principles and incorporate them into lesson planning and instruction, delving deeply into historical context and the relevance of know-

ledge points in the present to help students understand that science and technology cannot be separated from society and the environment [12]. STSE education concepts can subconsciously enhance students' sense of participation, strengthen students' sense of social responsibility, meet the needs of students' core literacy development, and prepare students to better adapt to modern life in the future [13]. All six versions of the Energy and Sustainable Development textbook cover STSE education to varying degrees, but the content is unevenly distributed, with three versions of the textbook setting up special STSE sections. According to the connotation of STSE, the contents of STSE in the three versions of the textbooks were classified thematically [14], as shown in **Table 5**.

In terms of "energy and sustainable development", the number of STSE contents in the People's Education edition is relatively small, and it favours the introduction of technology and social production themes, with only "automobiles causing pollution to the environment while consuming a lot of energy" being introduced. It is difficult for students to comprehend the environmental impact of scientific and technical advancement, which is detrimental to the development of students' sense of responsibility for sustainable development.

The Shanghai Science and Technology edition has a moderate quantity of STSE content that focuses on technology and the environment. The Shanghai Center Building blends physics and technology, making it simple for students to understand the two's complementing relationship. Pollution and treatment of the Suzhou River focus on environmental protection and attract students' attention to the concept that pollution prevention and promotion of sustainable development are more essential than pollution treatment.

The Shanghai Science and Education edition's STSE content is the most extensive, comprehensive, and evenly dispersed in terms of topics. The STSE section of the Shanghai Science and Education Edition focuses on the advancement of physical knowledge and human production and activities, in contrast to the People's Education Edition and the Shanghai Science and Technology Edition, but the technologies mentioned there are somewhat out of date and difficult to keep up with the advancement of the times [15].

Table 5. STSE presentation of textbook versions.

	Regular column	quantities	element	thematic
People's Education edition		1	Automotive and Energy	Technology, Society, and Environment
Shanghai Science and Education edition	STSE	3	Air quality indicators	Society, Environment
			Several new sources of energy	Science, Technology
			environmental protection label	Environment
Shanghai Science and Technology edition		2	Shanghai Center Tower	Technology, Society
			Suzhou Creek Pollution and Treatment	Environment

6. Conclusions

The six editions of the new high school physics textbook are judged to be able to meet the requirements of the new curriculum on “energy and sustainable development” after reading the new curriculum and performing a comparative study of the six editions. The chapter logic, substance, examples, exercises, and STSE columns vary, nevertheless. All things considered, the People’s Education edition and Shanghai Science and Education edition offer content the most logically and in a progressive manner that is consistent with the laws governing students’ physical and intellectual development. The Luke edition gives students greater consideration when choosing exercises. In addition, the STSE section should contain a comprehensive range of topics, and the content should be kept up to date so that students can have a deep understanding of the impact of science and technology on social progress and the environment.

Following that, I will integrate the benefits of each version of the textbook through textbook comparison, as well as integrate and make secondary development and utilization of the textbook’s resources, and apply them to the teaching practice, to help students better build awareness of environmental protection and the concept of sustainable development.

Conflicts of Interest

The authors declare no conflicts of interest.

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