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Compiling Self-Study Materials In Physics For High School Students In Vietnam

Dr. Tran Thi Kiem Thu
Faculty Of Physics Education, School Of Education, Can Tho University, Vietnam

Dr. Nguyen Duy Sang
Faculty Of Mathematics And Informatics Education, School Of Education, Can Tho University, Vietnam

Abstract:
The rapid expansion of human knowledge has meant that teachers are no longer confined to the role of knowledge transmitters; instead, they should serve as guides, supporting students by designing and providing effective self-study materials. This paper discusses the essential structure of such materials, which may include Open Educational Resources (OER), teacher-created resources, various types of virtual experiments, self-assessment tests, and the application of generative AI for assessment and translation. We also propose several illustrative examples of how self-study materials in Physics can be designed. These exercises aim to deepen students' subject knowledge, develop their ability to process and search for information not readily available in current textbooks, and thereby enrich the resource base that supports students in achieving advanced learning goals in the subject.
Keywords: *Student competence, specific heat capacity, self-study materials, Physics, heat.*

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I. Introduction

Self-study is an active process of bringing multiple perspectives and viewpoints into play to explore and re-examine beliefs, assumptions, ways of living, and understandings that are often taken for granted. In doing so, self-study carries both personal and professional significance: it enables us to reflect on ourselves and our practices while opening new pathways for action (Taylor & Diamond, 2020). It is both a perspective and a methodology that can broaden the ways in which we understand the world (Berry & Kitchen, 2023).

According to Đo Huong Tra and colleagues, one of the key requirements of a lesson designed using the competency-based approach is to emphasize activities that involve inquiry, experiential exploration, and, in particular, the application of knowledge to solve situations connected to real-life contexts. It also stresses self-directed learning through the collection, search, and processing of information (Đo, 2016, pp. 11–12). To foster self-learning competence, teachers may employ various strategies, one of which is the development of self-study materials and the organization of learning activities for students (Phan & Tran, 2023). Alongside the growth of information and communication technology (ICT), the increased integration of ICT and digital transformation has created breakthroughs in educational innovation, positively and comprehensively influencing methods of operation, quality, and effectiveness in education. These technologies support teachers in enhancing students' self-learning competence through blended learning approaches, such as ICT training (e.g., designing e-learning lessons, creating websites) and developing exercise systems aligned with the criteria of self-learning competence (Nguyen et al., 2024).

In this paper, we focus on analyzing and addressing the following research questions:
What types of self-study materials can teachers design in the process of teaching Physics?
What is the significance of these self-study materials?
How do teachers specifically design and develop such materials?

II. Content

Concept of Self-Study Materials

According to Phan Thi Thanh Hoi and Tran Thi Yen, self-study materials are resources that provide guidance and orientation for the learner's self-study process, enabling them to independently acquire knowledge as well as to develop and strengthen their self-learning competence (Phan & Trần, 2023).

In self-study materials, teachers may include links to Open Educational Resources (OER). According to UNESCO, OER refers to learning, teaching, and research materials in any format or medium that are either in the

public domain or released under an open license, permitting free access by others (Unesco.org). Specifically, as noted by the National Library of Vietnam, open-access resources can take many forms, including texts, software data, audio, images, multimedia, scientific materials, courses, research results, YouTube content, and even drafts of such materials.

Key Features of Self-Study Materials

According to Hinabahen Patel and Shivkumar Singh, the chapters of a current textbook or coursebook are often presented in a condensed format, typically organized by topic rather than designed to facilitate learning. The authors suggest that self-study materials function as a learning tool that is self-motivating, feasible, scientific, self-explanatory, and self-evaluative (Table 1) (Patel & Singh, 2022).

Table 1. *Key Features of Self-Study Materials*

Key Features	Specific description
Motivational aspect	Students will find self-study materials to be motivating and encouraging, much like having a teacher providing direct instruction. The materials should spark their curiosity, pose questions, connect what they are learning with what they already know, and give them a reason to learn.
Feasibility and ease of use	In addition to providing information, the materials also offer support in the form of a learning guide, including suggestions and references to help learners study more effectively. They are accompanied by simple explanations, such as illustrations and activities, to make the content easier to understand.
Scientific and logical	In addition to providing information, the materials also offer support in the form of a learning guide, including suggestions and references to help learners study more effectively. They are accompanied by simple explanations, such as illustrations and activities, to make the content easier to understand.
Self-explanatory	Self-study materials must provide learners with sufficient guidance, suggestions, and recommendations at every stage of the learning process. They should be presented in an explanatory manner and developed sequentially in accordance with the structure of the content.
Self-assessment	To achieve optimal learning outcomes, learners must know whether they are on the right track. Through the use of self-assessment tools, such as self-check questions and exercises, they can receive essential feedback on their progress, reinforce their learning, and stay motivated to continue. The course instructor should prepare "feasible answers" or "sample answers" for the questions, exercises, and activities provided at the end of each lesson so that students can check their responses and evaluate their learning progress.

The Role of Self-Study Materials

Sunil Kumar Bhat from the National University of Singapore emphasizes that self-study materials play a crucial role. One example he mentions is the publication of a large number of Hindi textbooks (the official language of India) designed for non-Hindi speakers-all of which are self-study resources. There are very few textbooks specifically written for teaching Hindi. Hindi teachers around the world must rely on self-study materials, adapting and modifying them for classroom teaching purposes.

The author suggests that self-study materials can take two forms: textbooks (used either as formal textbooks or as self-study books) and PowerPoint presentations (Bhat, 2012). The structure of a self-study book may include 15 lessons, 6 CDs, answer keys, and PowerPoint slides intended to complement the textbook. In other words, PowerPoint serves as supplementary material to enhance interactivity, motivation, and communication. The inclusion of PowerPoint aims to boost learners' motivation, enable natural learning, and provide a supportive context for the learning process.

According to UNESCO, the creation of self-study materials should be encouraged in all subjects, especially in developing countries. A well-designed learning resource can help compensate for other shortcomings, such as low teacher qualifications, parents' limited educational background, and inequality caused by the wealth gap between regions. Learning and teaching materials (LTM) should be based on both learning theory and the specific content theory of the subject. They should provide diverse applications of concepts and principles, enable the active and equitable participation of all learners, and guide them to reflect on what they are learning (UNESCO, 2025).

Comparison Between Self-Study Materials and Regular Materials

Based on studies on self-study materials, we believe that self-study materials share certain similarities and differences with regular learning materials. We have compiled a comparison of these two types of materials, as presented in Table 2.

Table 2. *Some Differences Between Self-Study Materials and Regular Materials*

Self-study materials	Regular materials
- Provides subject content along with a systematic set of self-study guiding questions, the knowledge to be studied, and self-assessment questions.	- Provides subject content but does not serve the function of guiding self-study.

- Content is written with a clear self-study orientation, making it easier for students to engage in self-learning and self-assessment to achieve the intended goals.	- Content is not written with a self-study orientation, causing students to become unfocused due to the overwhelming volume of knowledge, making it difficult to achieve the learning objectives.
- Teaching is differentiated; if students complete simpler tasks, they can move on to more challenging exercises, while customizing individual adjustments such as resources, formats, space, and time to achieve the best learning outcomes.	- Cannot, or can hardly, facilitate differentiated instruction.
- Each lesson incorporates self-check exercises integrated throughout from beginning to end. Thus, after each lesson or even the smallest unit of knowledge, students can determine whether they have understood the material and make timely adjustments.	- Assessing students' self-study outcomes is challenging; students do not know how to self-check their acquired knowledge and cannot promptly address gaps in their understanding.

III. Research Results

Structural Diagram of Self-Study Materials Supporting Physics Teaching

We propose that self-study materials consist of the following components:

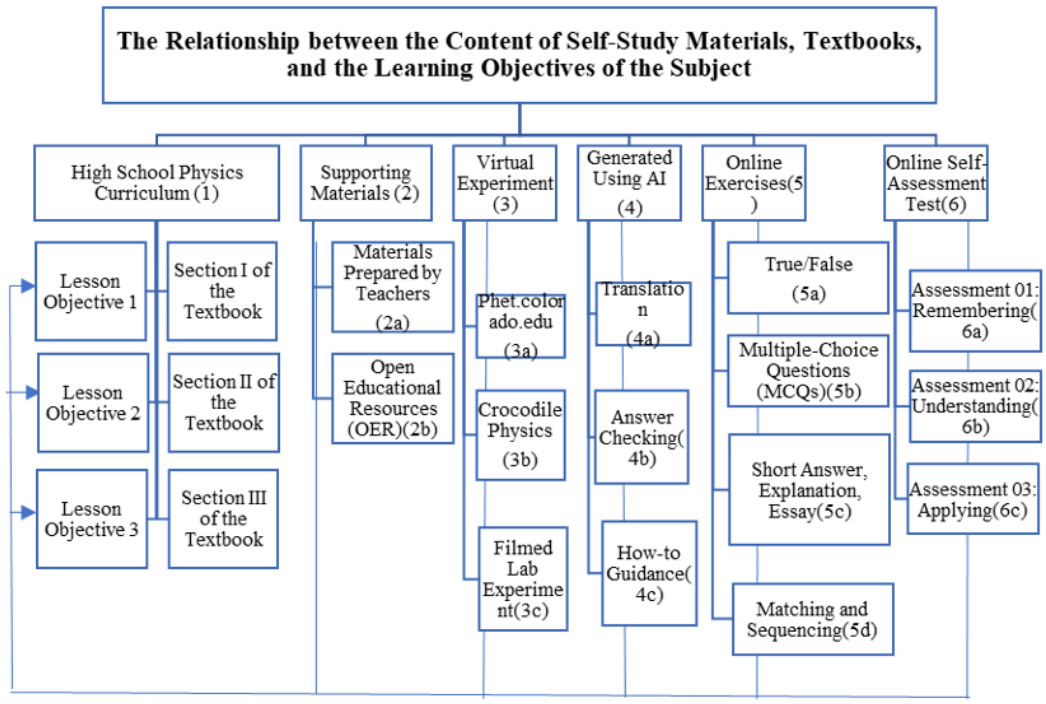


Diagram 1. Structure and Components of Self-Study Support Materials

A self-study material for a specific content unit does not necessarily have to include all the components described in Diagram 1. The choice of components depends on the lesson content. For example, a lesson involving circuit diagrams or experiments measuring current and voltage to derive Ohm's law may utilize components (3a), (3b), or (3c). Conversely, if the lesson deals with complex issues, highly abstract concepts, or in-depth theoretical research, teachers should opt for materials of type (2b) and (4a).

Regarding the organization of teaching oriented toward developing students' competencies, activities should be varied, including experiments, discussions, information exploration, creative tasks, inquiry, discovery, practice, reception, imagination, and reflection (Đo et al., 2019, p.21).

Analysis of the Content on "Specific Heat Capacity" within the 12th Grade Thermal Physics Unit

Specific heat capacity is a common physical quantity encountered in thermal problems. Students learning about the specific heat capacity unit and conducting experiments to determine it develop core, fundamental, and essential physics competencies. However, specific heat capacity cannot be considered in isolation from other quantities such as heat, temperature, and mass (or volume and density). Therefore, in exercises that concretize the required learning outcomes, incorporating related real-world issues contributes to the development of students' physics competencies, general skills, and personal qualities.

Table 3. *Learning Outcomes in the Physics Curriculum for the "Specific Heat Capacity" Knowledge Unit*

Physics Curriculum Objectives	Essential Materials
State the definition of specific heat capacity.	Textbook
- Discuss to design or select an approach and carry it out, measuring the specific heat capacity using laboratory equipment.	Textbook
Self-Study Materials to Support Students	
Explain the practical applications of specific heat capacity (Supplementary learning outcome for advanced classes, physics-specialized courses, or natural science talent classes).	Type (3a): Virtual experiment with PhET Type (4c): AI-supported self-study Type (6c): Application exercise Type (2a): Extended exercise sheet Type (5c): Short-answer explanatory responses

Compiling self-study materials in physics: Energy – Specific Heat Capacity Section

The materials are structured to include practical application exercises, which teachers can use before or after classroom instruction. They can be provided in text format or digitally, such as through website designs or e-learning lessons.

What Is Thermal Pollution?

Water pollution is one of the major issues in environmental science. Pollutants are released into the environment in various ways, contaminating groundwater, streams, rivers, lakes, and oceans. A primary concern is the loss of safe drinking water, also referred to as clean water for humans, followed by the destruction or alteration of ecosystems. Additionally, there is another type of pollution that can harm aquatic life: thermal pollution.

Consider the following scenario: A volume of water of approximately 1.1×10^5 kg at x°C is discharged from a power plant into a nearby lake containing 3.0×10^4 m³ of water, initially at 15.5°C. According to engineers' recommendations, the lake's temperature should stabilize between 20°C and 27°C. Determine the range of temperatures x°C at which the power plant can release water so that the fish in the lake do not die from thermal pollution.

Learning Objectives and Teaching Methods: The specific heat capacity of water is approximately 4200 J/kg·K; from this, the temperature of the wastewater discharged from the power plant within the permissible range can be calculated using the thermal equilibrium equation $Q_{released} = Q_{absorbed}$. Although this is a simple problem, it serves to cultivate students' responsibility for environmental protection, highlighting that water pollution is not only caused by chemical discharges into rivers but also by abnormal temperature increases from nearby industrial plants released into ponds and lakes. Through this, students develop environmental awareness.

Teaching Methods: Teachers can use blended learning or implement it through a Flipped Classroom model.

Self-Study Materials with a Virtual Experiment Comparing the Specific Heat Capacities of Two Different Objects

The figure 1 shows an experiment comparing the specific heat capacities of two different substances. Use AI to assist in explaining, translating, proposing the experimental procedure, recording the results, and making observations.

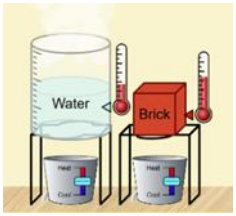


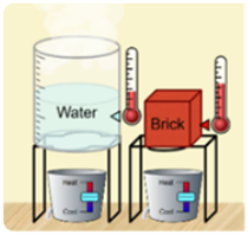
Figure 1. *Experiment Investigating Specific Heat Capacity*

Learning Objectives and Teaching Methods: Students should be able to observe the differences in specific heat capacities of substances using laboratory equipment. Teachers organize for students to practice via computer or mobile devices before coming to class. Specifically:

Step 1: Access the link: https://phet.colorado.edu/sims/html/energy-forms-and-changes/latest/energy-forms-and-changes_all.html

Step 2: Set up the experiment as shown in the figure.

Use AI for translation. The results obtained are as follows:



This picture shows an **experiment comparing heat absorption of water and a brick**.

- On the **left**, there is a container of **water** being heated with a burner, and a thermometer measures its temperature.
- On the **right**, a **brick** is being heated in the same way, also with a thermometer.
- The setup allows us to see how **different materials heat up differently** when the same amount of heat i applied.

👉 It demonstrates the concept of **specific heat capacity**:

- Water has a **high specific heat capacity**, so it takes longer to heat up but also stores more heat.
- Brick has a **lower specific heat capacity**, so it heats up faster but doesn't store as much heat.

Figure 2. *Using AI to help students understand the meaning of the experiment provided by the teacher.*

Preliminary Conclusion**:** Using AI helps save translation time, and the images provided by the software explain the terminology and the meaning of the experiment, allowing students to clearly understand how the experiment is conducted and the role of the experiment above.

Step 3: Students observe the experiment and answer the question: *How can we determine that the specific heat capacity of water is higher than that of brick?* (Note: This question also aligns with the AI-generated comment.)

Students' expected procedure: When using the mouse to increase the heat source, it can be observed that, at the same level of heat input, the thermometer on the left rises much more slowly than the thermometer on the right. From this, students can conclude that water absorbs more heat than brick, or in other words, to raise the temperature by 10°C, more heat must be supplied to water than to brick.

Teaching Objectives and Methods: The aim is to compare the differences in specific heat capacities of substances using practical tools, or in other words, to develop students' competence in exploring the natural world from a physics perspective through virtual experiments. Students engage in self-study and inquiry, learning that different substances have different specific heat capacities, and that for a given substance, the specific heat capacity is a constant. Teachers can utilize information technology to conduct online teaching and create questions through e-learning platforms or educational websites.

Teachers may also apply the Just-in-Time Teaching (JiTT) model, in which they prepare a set of warm-up exercises on a digital platform (usually web-based) and require students to complete them before class. Based on students' responses and feedback, teachers can identify common answers, mistakes, difficulties, and obstacles, and use this information to design appropriate in-class activities (Mai & Vo, 2019).

Teacher-Prepared Knowledge Support Sheet

For the purpose of helping students better understand and gain additional information related to the lesson, teachers need to prepare self-study materials in the form of knowledge support resources. These materials should be edited and adapted to suit students' cognitive characteristics. They do not necessarily need to include questions or academic exercises; rather, they simply expand the scope of the lesson slightly beyond the content provided in textbooks or workbooks.

For example, in Grade 12 Physics, the curriculum aims for students to *apply the first law of thermodynamics in some simple cases* (page 24, National Curriculum for Physics). However, applications of the second law are not yet covered. If possible, teachers can find suitable opportunities to introduce the existence of the second law to students through self-study materials.

Example: At the beginning of the 19th century, the German physicist Rudolf Clausius formulated the second law of thermodynamics as follows: *"A cyclic process whose only result is the transfer of heat from a body*

at a certain temperature to a body at a higher temperature is impossible," or *"The total entropy of a system increases or remains constant in any spontaneous process; it never decreases."* Entropy is a physical quantity that characterizes the disorder of a system: the more disordered a system is, the higher its entropy, denoted by S.

Living organisms continuously develop and grow over time. Within living systems, from small molecules to macromolecules, everything is arranged in a highly ordered manner. This seems to contradict the second law of thermodynamics, which states that an isolated system must always evolve from order to disorder—that is, entropy must increase or remain constant. However, living organisms carry out non-equilibrium processes in which order is maintained or even increased because the organism is an open system, exchanging energy and matter with its environment.

Questions for students:

Question 1: What is entropy? According to the second law of thermodynamics, entropy should always increase or remain constant, so living organisms should become disordered. In reality, organisms are highly ordered at the molecular level. How do living organisms prevent the increase of entropy within their bodies?

Question 2: Entropy has been used to show that cancer cells cannot undergo entropy changes at the same level as healthy cells. Therefore, changes in entropy can serve as a prognostic tool, providing a measure of malignancy. What are malignant cells, and what causes their formation?

Teaching method: Guide students to use search tools to select and process relevant information in order to answer the two questions above.

IV. Conclusion

Designing self-study materials is not a mandatory task but is essential for teachers in general and for physics teaching in particular. Developing practical applications and ways to clarify the learned theory cannot replace textbooks, but such materials serve as "satellite content" that helps reinforce, practice, and explain concepts for students. At the same time, they contribute to developing students' competencies, including the ability to explore the natural world, general skills such as autonomous learning, curiosity, and qualities like diligence, honesty, and responsibility.

To carry out this task effectively, each subject-specialist team should establish a council to contribute ideas, create diverse teaching content, assign exercises, and monitor learning progress to achieve the curriculum's objectives at a medium or higher level.

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