

## BUILDING PROBLEM-SOLVING COMPETENCY FRAMEWORK IN SUSTAINABLE DEVELOPMENT EDUCATION FOR HIGH SCHOOL STUDENTS

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**Abstract.** Problem-solving ability is one of the common competencies that play a particularly important role in demonstrating learners' ability to perceive and explore problematic situations in learning and life. Sustainable development education has many opportunities to foster problem-solving abilities for students because “in sustainable development education, people learn to know, learn to assert themselves, learn to work together, live together, learn to do and learn to change themselves and society”. The article proposes a problem-solving competency framework in education for sustainable development. This framework contributes in terms of theoretical and practical basis in organizing the implementation of sustainable development education in the high school program to meet the goal of competency development in students.

**Keywords:** competency, competency framework, education for sustainable development, problem-solving competency in education for sustainable development.

### 1. Introduction

Sustainable development is becoming a common trend in many fields. Education plays an important role in the process of achieving sustainable development goals and has a central role in helping individuals change their thoughts and actions towards sustainable development [1]. Therefore, education is considered an objective and a means to achieve the goals of Sustainable Development. Sustainable Development Education prepares learners to become more responsible citizens not only for themselves but also for future generations [2], using scientific and technological knowledge to solve practical problems. Environment, economy, and society are the three components of sustainable development. The authors Rauch, Streissler, and Steiner assert that competence does not exist independently but is always associated with the teaching context, school, culture, and society [3]. Many studies have shown that problem-solving is a common element of many approaches in sustainable development education (ESD).

However, in reality, fostering and assessing problem-solving competency in sustainable development education is still facing difficulties because there has not been a standardized and used framework for problem-solving competency in sustainable development education. Therefore, it is very necessary to build a problem-solving competency framework in sustainable development education for students. The article presents the perspective on problem-solving competency in the goal of sustainable development and gives the process of building a competency framework and competency structure for problem-solving in ESD.

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## **2. Content**

### **2.1. Problem-solving competency in education for sustainable development**

Problem-solving competency is one of the important competencies that need to be fostered for students. Many authors have studied problem-solving competency. According to KhongViLay Volayuth and Tran Trung Ninh, "Problem-solving competence is an individual's ability to effectively use cognitive processes, actions and attitudes, motivations, and emotions to solve situations where they are not available. common processes, procedures, solutions" [4]. PISA (2003) stated that "Problem-solving competency is the ability of an individual to use the cognitive process to face and solve problems in real life, interdisciplinary" [5]. According to Do Huong Tra and colleagues, "Problem-solving ability of a student is understood as the general mobilization of knowledge, skills, attitudes, and emotions of that student to solve practical situations in contexts to which specific solutions are not immediately available" [6]. Although there are different descriptions of the term problem-solving competency, the overall results lead to the same notion that problem-solving is a general capacity that demonstrates each person's ability to perceive and discover situations that have problems in learning and social context without a prior orientation of results, and finding solutions to solve the problems posed in that situation, thereby demonstrating the ability to think, cooperate in choosing to select and decide the optimal solution [7].

In Sustainable Development Education, the goal is to change behavior to create a sustainable society for everyone on the basis of socioeconomic, environmental, and cultural connections through the impact on all aspects of social life to integrate sustainable development values into all areas of learning. Thus, competency in sustainable development education is a combination of cognitive skills, the ability to act, ethical values, and attitudes that are mobilized to solve a real-life situation or context related to sustainable development [8].

In our opinion, problem-solving competency in Sustainable Development Education is the ability to mobilize knowledge, skills, attitudes, and emotions to propose and implement practical problem-solving solutions in learning situations or specific contexts that help promote the goals of Sustainable Development.

### **2.2. The process of building a framework for problem-solving competency in education for sustainable development**

#### **2.2.1. The scientific basis of the proposal to build a competency framework**

Firstly, based on the content of competence: Competence is the "ability to act" [9, 10], is a collection of knowledge, skills, and experiences necessary for future actions, and is expressed through activities [11]. Therefore, the structure of competence is expressed in terms of observable, quantifiable behavior;

Second, based on the sequence of problem-solving: Find out the problem - Provide solutions to solve the problem - Make an implementation plan - Evaluate and check the results of problem-solving [12]. Problem-solving competency of students in teaching is shown through activities of the problem-solving process. Therefore, the problem-solving competency structure is based on the following steps: identifying the problem and the goal of the problem to be solved; collecting information and analyzing to come up with solutions; selecting the optimal solution among the proposed solutions for implementation; evaluating the results obtained, learn from experience when dealing with other similar problems and propose new problems when necessary;

Third, based on the goal of sustainable development, practical issues are identified with the community and locality.

**2.2.2. Principles of proposing a framework for problem-solving competency in sustainable development education**

Problem-solving competency structure in Sustainable Development Education is proposed based on the following principles:

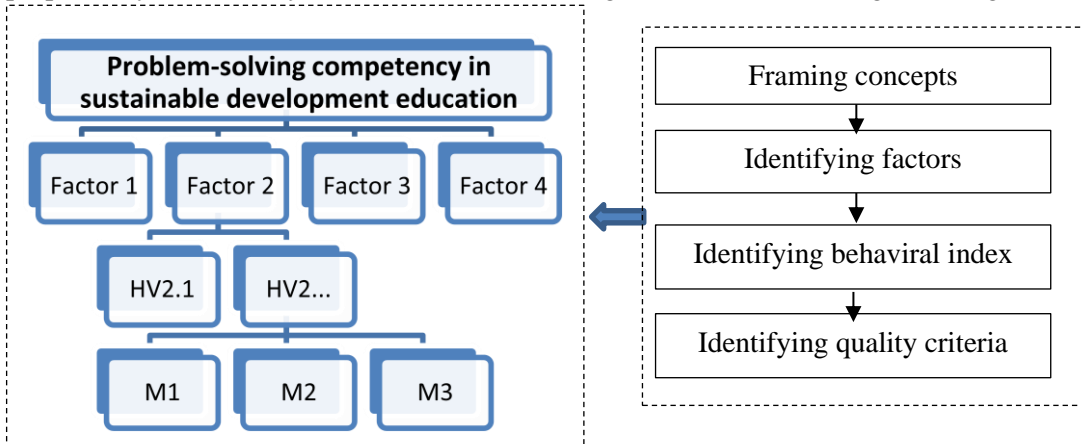
*Firstly*, ensuring the systematic, scientific, and logical character expressed in the correlation between the component competencies, behavioral indicators, and quality criteria of behaviors;

*Second*, ensuring pedagogy is in accordance with the psychophysiological characteristics of high school students;

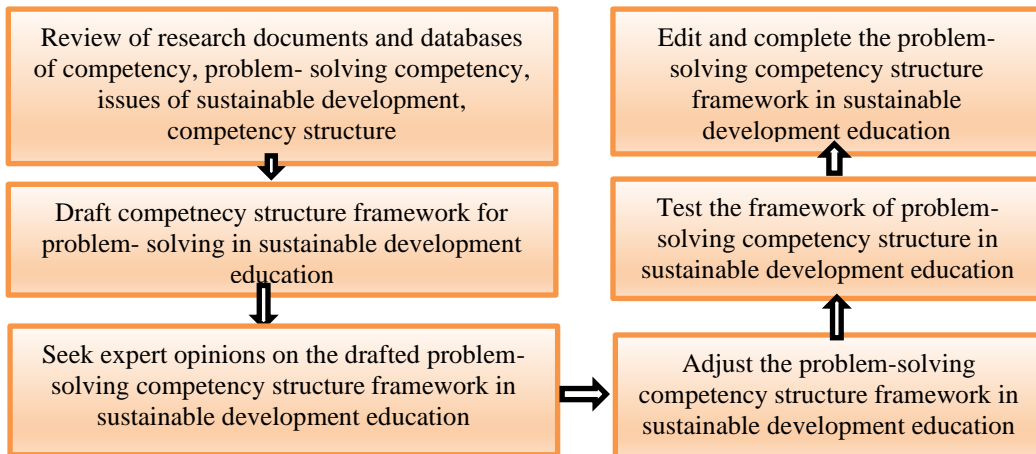
*Third*, ensuring value and reliability: following suggestions from experts in the field of theory and teaching methods of Physics and through surveys of physics teachers directly teaching high school programs.

**2.2.3. The process of building a framework for problem-solving competency in sustainable development education**

The process of building the structure of problem-solving competency in sustainable development education was built concerning the process of building competency structure suggested by Nguyen Van Bien [13], the process of building a document competency structure proposed by the Ministry of Education and Training [14], described through the diagram below:



*Figure 1. Process of building problem-solving competency framework in ESD*



*Figure 2. Steps to build problem-solving competency framework in ESD*

*Step 1.* Literature review and theoretical basis of competency, problem-solving competency, problem of sustainable development, competency structure.

*Step 2.* Draft competency framework for problem-solving in sustainable development education.

On the basis of the studies from step 1, studying the draft problem-solving competency framework in Sustainable Development Education includes 4 components (detecting problems, sustainable development; Proposing solutions to solving problems of sustainable development; Implementing solutions to problems in sustainable development education; and Assessing the problem-solving process of sustainable development, detecting the problem of sustainable development requires handling) with 10 behavioral manifestations.

*Step 3.* Seeking expert opinion on the draft framework of problem-solving competency of Sustainable Development.

To test the value of the problem-solving competency framework of Sustainable Development, on the adequacy and rationality of the proposed components, we consulted a number of experts. The experts are researchers in the field of Theory and teaching methods of Physics with 15-45 years of working experience. Regarding the structure of the competency framework, some experts believe that component 4 should be separated into 3 behaviors: the behavior of assessing the problem-solving process of sustainable development and discovering new problems of sustainable development, need to be resolved separately into assessment of changes in awareness, attitude, and behavior in accordance with the goals of sustainable development and discovery of new problems that need to be solved decide.

*Step 4.* Adjusting the problem-solving competency framework in Sustainable Development Education

After consulting experts, the study synthesized, analyzed, explained, absorbed, and edited the contents, and adjusted the structure of problem-solving competency in sustainable development education including 4 component competencies and 11 behavioral indicators with 03 levels of quality criteria for each behavior.

*Step 5.* Testing the problem-solving competency structure framework in Sustainable Development Education. To check the appropriateness of the problem-solving competency scale in sustainable development education according to behavioral indicators and quality criteria, the study was surveyed to investigate the feasibility of each level of behavioral expression of problem-solving competency in sustainable development education in teachers. The survey sample is 64 teachers teaching Physics at the high school level in Hai Duong province, at regional schools in Hai Duong province and a few neighboring provinces. 4-level Likert scale tool (neutral level removed). Collected data were entered and coded on an Excel application and processed by SPSS software. Cronbach's Alpha correlation coefficient was analyzed to remove null variables. The results of testing the reliability of the problem-solving competency structure in sustainable development education are shown in Table 1.

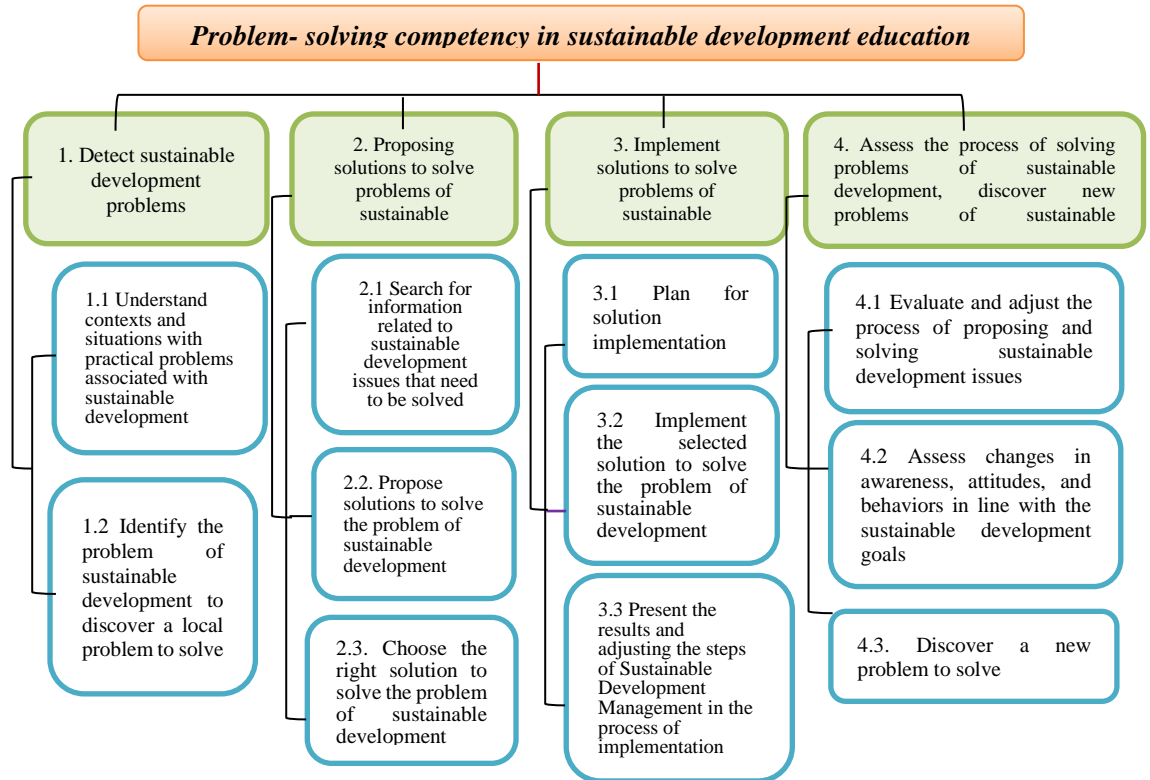
The survey results show that Cronbach's Alpha coefficient = 0.808 is in the range of 0.8 to 1, proving that the criteria set out are closely correlated with each other, and the scale can be measured. No variable has a Cronbach's Alpha if the Item Deleted coefficient is greater than the sum of Cronbach's Alpha coefficient and the matched Corrected Item-Total Correlation coefficient (both greater than 0.3). The analysis data shows that the behavioral manifestations are closely correlated with each other, measuring the same hidden variable as problem-solving competency in sustainable development education, and no behavior is removed.

**Table 1. Results of testing the reliability of the scale of problem-solving competency in ESD**

<b>Reliability Statistics</b>				
Cronbach's Alpha		N of Items		
.808		11		
<b>Item-Total Statistics</b>				
	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
1.1. Examining contexts and situations with practical problems associated with sustainable development in the locality.	35.0000	8.571	.682	.774
1.2. Discovering the problem of sustainable development to discover a local problem to be solved.	34.7188	9.063	.346	.807
2.1. Collecting information related to the problem of sustainable development to be solved.	34.8281	8.875	.440	.796
2.2. Proposing solutions to solve the problems of sustainable development.	34.8438	8.737	.531	.787
2.3. Selecting appropriate solutions to solve sustainable development problems.	34.7656	8.912	.459	.794
3.1. Making a plan to implement the solution.	34.8438	8.705	.501	.790
3.2. Implementing the selected solution to solve the problem of sustainable development.	34.6563	8.991	.446	.795
3.3. Presenting the results and adjusting the steps of sustainable development management in the implementation process.	34.6250	9.127	.406	.799
4.1. Evaluating and adjusting the process of proposing and solving sustainable development issues.	34.7188	9.285	.331	.807
4.2. Evaluating changes in awareness, attitude, and behavior in accordance with the goals of sustainable development.	34.7656	8.849	.482	.792
4.3. Discovering new problems to solve.	34.8906	8.607	.595	.781

**Step 6. Editing and completing the problem-solving competency structure framework in Sustainable Development Education**

Analyzing expert opinions, through the results of a survey of teachers, after editing and perfecting the problem-solving competency structure framework in sustainable development education, we propose a problem-solving competency structure framework in sustainable development education as shown in the diagram below.

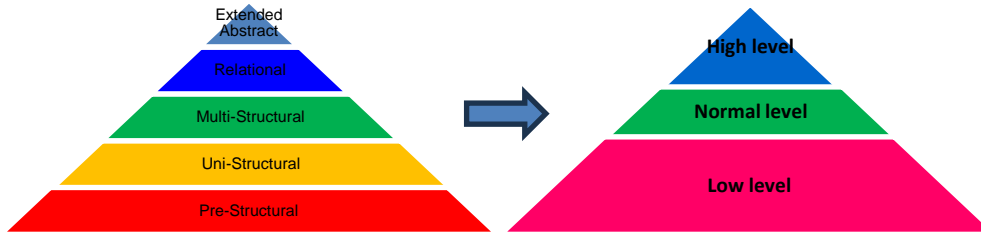


**Figure 3. Structure of problem-solving competency in sustainable development education**

**2.3. Structure of problem-solving competency in education for sustainable development**

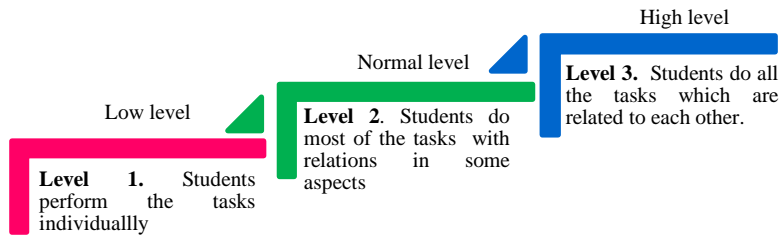
Problem-solving competency structure in Sustainable Development Education includes 4 component competencies and 11 behavioral indicators with 3 levels in each behavior. To describe the level for each behavior, the thesis first builds a general structure for each of them. Classification of learning outcomes according to the SOLO (Structure of the Observed Learning Outcome) scale includes 5 levels [15]: Pre-Structural, Uni-Structural, Multi-Structural, relationship (Relational), and open abstraction (Extended Abstract). The behavioral quality grading measures learning outcomes according to their complexity, not the number of correct answers in a particular task or activity.

The levels of learning outcomes are measured using SOLO taxonomy. However, the 5-level SOLO taxonomy can be reduced to 3 general levels (low-medium-high). This is a way to create more generalization and simplification in the evaluation and classification of data represented by the flexibility of dividing into 3 levels (creating clearer groupings, allowing for better classification, easy classification, and comparison) and making clear distinctions between the levels.



**Figure 4. The SOLO taxonomy application model divided into 3 levels**

Specifically, behavioral quality criteria are classified into three levels from low to high. The division of Behavioral quality criteria is classified into three levels from low to high. The division of behavioral quality criteria of problem-solving competency in ESD is as follows.



**Figure 5. Levels of problem-solving competence behavior in ESD**

The structure of problem-solving competency in sustainable development education is presented in Table 2:

**Table 2. Problem-solving competency structure in Sustainable Development Education**

Component competency	Behaviour	Cognitive levels		
		Level 1	Level 2	Level 3
1. Detecting sustainable development problems	1.1. Examining contexts and situations with practical problems associated with sustainable development in the locality.	Recognizing some fragmentary information about contexts and real-life situations.	Stating information about the context and practical situations in the locality.	Stating information about the context and practical situations associated with sustainable development that need to be resolved in the locality.
	1.2. Discovering the problem of sustainable development to discover a local problem to be solved.	Presenting the problem of sustainable development to be solved.	Presenting the problem of sustainable development to be solved in accordance with the local context.	Analyzing sustainable development issues that need to be solved in accordance with the local context.

2. Proposing solutions to solve problems of sustainable development	2.1. Collecting information related to the problem of sustainable development to be solved.	Describing Knowledge and methods of solving sustainable development problems.	Describing knowledge and methods of solving sustainable development problems and evaluating that information source.	Selecting knowledge and methods of solving sustainable development problems and evaluating information sources.
	2.2. Proposing solutions to solve the problems of sustainable development.	Presenting 01 solution to solve the problem of sustainable development.	Presenting the solutions and stating the basis of the proposal	Presenting the solutions and giving a reasonable basis for the proposal.
	2.3. Selecting appropriate solutions to solve sustainable development problems.	Analyzing solutions suitable to the resources of the school, locality, and community.	Analyzing solutions that are appropriate and feasible to the resources of the school, locality, and community.	Analyzing solutions that are suitable with the resources of the school, locality, and community and are feasible, without affecting the next generation.
3. Implementing solutions to solve problems of sustainable development	3.1. Making a plan to implement the solution.	Determining the goals, content, and time to implement the solution into a plan.	Determining the goals, content, and time to implement the solution, and specifying detailed steps.	Determining the goals, content, and time to implement the solution, specifying the detailed steps, and assigning tasks to members in the spirit of cooperation and participation.
	3.2. Implementing the selected solution to solve the problem of sustainable development.	Implementing the solution according to the selected plan.	Implementing the solution according to the selected plan with reliable support resources.	Implementing a solution to a succession of problems with trusted support, some of which arise from the implementation itself.
	3.3. Presenting the results and adjusting the steps of sustainable development management in the implementation process.	Presenting research results.	Presenting research results; detecting errors and difficulties in the implementation process.	Presenting research results, detecting errors, and difficulties in the implementation process, and making adjustments.

4. Assessing the problem-solving process of sustainable development, and discovering new problems of sustainable development needs to be resolved	4.1. Evaluating and adjusting the process of proposing and solving sustainable development issues.	Processing some research results, and detecting errors and difficulties.	Processing some research results, detecting errors and difficulties, and identifying possible adjustments.	Processing some research results, detecting errors, and difficulties, and identifying and making adjustments.
	4.2. Evaluating changes in awareness, attitude, and behavior in accordance with the goals of sustainable development.	Presenting the meaning of the implemented solution to life, society, and community.	Explaining the meaning of the implemented solution to life, society, and community.	Explaining the meaning of the solution implemented to life, society, and community in accordance with the goal of sustainable development.
	4.3. Discovering new problems to solve.	Proposing the applicability of the solution in new situations.	Proposing the applicability of the solution in new situations and detecting difficulties and problems.	Proposing the applicability of the solution in new situations, discovering difficulties and problems and expressing new problems to be solved.

## 2.4. Discussion

The research aims to build a competency framework for problem-solving in sustainable development education, both as a basis for organizing competency-building training for sustainable development and as a tool for assessing problem-solving competency in sustainable development education. The results show that Cronbach's Alpha coefficient = 0.808 showing that the criteria set out are closely correlated with each other as analyzed above. The components constituting problem-solving competency in sustainable development education are similar to problem-solving competency in general. However, the difference between these two structures is reflected in some levels of cognitive learning outcomes. Specifically, issues in sustainable development are in relation to the economy, society, and environment. Students can mobilize scientific knowledge to propose and implement solutions to solve problems on sustainable development in the locality at present without affecting the next generation; emphasizing students' behavior change and interest in life in the community. This competency framework serves as a tool to measure and properly assess the competency of each student as required, but teachers can also design and choose methods of organizing teaching activities to foster these competencies.

To initially determine the usefulness of the proposed competency framework, the research has used the designed competency framework as the basis for organizing the teaching of knowledge content in the section "Effective and economical use of energy" according to the problem-solving process. Situation: According to the opinion of the Ministry of Industry and Trade on June 6, 2023: since the beginning of May, unprecedented hot weather has occurred in many localities across the country and unpredictable developments may continue until June. This situation has increased the demand for domestic electricity consumption, while the water flow to

hydropower reservoirs is very low, especially in the northern hydropower reservoirs, causing a great impact on electricity supply in the dry season of 2023, especially in the period until the end of May when imported coal is slower than demand. From the image of the energy label of the energy-consuming device, learners need to detect the problem: The Ministry of Industry and Trade of Vietnam mandates that all power-consuming devices on the market are issued with energy labels. What is the meaning of the energy label? Why is the energy label required on the device? What do energy labels tell consumers?

With this activity, behavior 1.1, 1.2 of component competency 1- Detecting sustainable development problems in the competency framework has the opportunity to be demonstrated.



T. air conditioner energy label S. air conditioner energy label H. air conditioner energy label

Figure 6. Energy labels on air conditioners of some brands

From understanding the situation, the teacher prompts students to discover the problem: The need to use energy economically and efficiently and how can energy be used economically and efficiently.

Proposing solutions: Students search for information, observe equipment, and the energy that equipment generates such as exercise machines, and energy from flowing water, ... propose and choose solutions: choose energy-saving products, and at the same time need to make good use of energy sources from activities in life.

With this activity, behaviors 2.1, 2.2, and 2.3 of component 2- Proposing problem-solving solutions in sustainable development education in the competency framework have the opportunity to be demonstrated.

Implementation of the solution: Students make a plan, determine operating principles, and implementation time, assign members, indicate intermediate steps to implement the solution; implement solutions, and present research results.

The results include:

- Finding out what it means to label features
- + Providing reliable information about the energy consumption of products to consumers. Consumers can compare the energy performance of different products and choose the more energy-efficient ones. This results in reduced energy consumption and cost savings for the consumer.
- + Encouraging the use of energy-efficient products: Energy labeling can encourage manufacturers to improve the energy performance of their products. Products that are highly rated for energy efficiency will attract consumers and create incentives for competing companies to develop more energy-efficient products.
- + Environmental protection: Using energy-saving products helps to reduce energy consumption and greenhouse gas emissions. Energy labels help consumers recognize and prioritize the use of environmentally friendly products, contributing to protecting resources and reducing environmental pollution.

- Inventing devices that utilize energy for daily use: a device to charge a phone while exercising, a mini generator that makes good use of the energy of domestic water to light bulbs in the basements of the classroom's area in the school.

Students' products have demonstrated the principle, and structure of the device as well as their usefulness (operable).



*Equipment that utilizes energy from exercise bikes*



*Model of equipment that utilizes energy from domestic water*



*Students experiment with the equipment*

**Figure 7. Products and product testing by student**

With this activity, behaviors 3.1, 3.2, and 3.3 of component 3- Implementing solutions to solve the problem of sustainable development in the competency framework have the opportunity to be demonstrated.

On the basis of the implemented solution, the groups evaluated and proposed to adjust the solution better, and actively participated in propaganda activities on economical and efficient use of energy such as responding to Earth Hour activities. Note that when choosing energy-consuming equipment, it is necessary to pay attention to the parameters on the energy label, and use compact bulbs instead of incandescent bulbs. Energy from devices around us can be fully utilized for life, but the generated competency is very small, only used in lighting bulbs or charging phones. However, that inexhaustible source of energy is renewable energy. HS proposes new problems to be solved in manufacturing equipment to exploit renewable energy sources.

With this activity, behavior 4.1, 4.2, and 4.3 of component 4 - Assessing the problem-solving process of sustainable development, and discovering new sustainable development problems that need to be solved in the competency framework have the opportunity to be demonstrated.

In the illustrative example, although the depth of understanding has shown that to foster problem-solving competency in sustainable development education, teachers need to organize teaching activities to lead students to discover problems from life experience. Through the problem-solving process, students reveal expected behavior. From there, teachers have a basis to evaluate problem-solving competency in sustainable development education based on established behavioral quality criteria. In contrast, behavioral quality criteria support teachers in guiding orientation in setting goals, designing activities, and assessing.

### **3. Conclusions**

Problem-solving competency is one of the core competencies that need to be formed for future citizens and this is also one of the general competencies required in the 2018 general education curriculum. On the basis of defining the concept of problem-solving competency in sustainable development education, and consolidating the process of building a competency structure framework, we have researched and proposed a problem-solving competency structure in sustainable development education including 4 component competencies, 11 behavioral

indicators, and 33 behavioral manifestations and illustrated the application of the structural framework to organize teaching to foster problem-solving competency in sustainable development education. The results obtained initially show the value and reliability of the problem-solving competency structure in sustainable development education that has been built. The results of the article will be a reference, helping teachers build the process of teaching the topic and design tools to assess problem-solving competency in students' sustainable development education. However, to build a teaching process to meet the goal of fostering problem-solving competency in sustainable development education, we will continue to do so in the next studies.

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