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The scientific process of building knowledge in the style of problem-solving teaching in some contents of Nuclear Physics

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Abstract: *Approaching the general trend of the world, Vietnam is building a competency-oriented education program at all levels to support and develop for learners systematic the necessary competencies to participate in the labor market during the integration period effectively. Problem-solving is one of the expected competencies that need to foster for students, especially problems associated with the major. For graduates to quickly adapt to complex, practical issues, they need practice solving such problems during their undergraduate years. The article has given the scientific process of building knowledge in the style of problem-solving teaching in some contents of Nuclear Physics as an illustrative example. The article results help lecturers refer to teaching General Physics and other subjects to meet the major's learning outcomes.*

Key Word*: problem-solving competency, problem-solving teaching, Nuclear Physics.*

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I. Introduction

Higher education is a decisive factor for the quality of human resources for the labor market, so most countries attach importance to this level of education. Depending on the conditions, circumstances and goals of each country, higher education has a development strategy in different aspects.The competency-based training program help students to be able to solve practical problems right after graduation.

To students to adapt to the labor market after graduation, they need to have the necessary knowledge, skills and expertise as described in the 21st century learning framework[1],[2]. One of the skills of the 21st century is problem solving. To form and foster this skill, the teaching method of problem solving in physics can meet this [3].

Problem solving follows basic steps, from understanding the problem, proposing a solution to the problem, and evaluating the entire process[4]. Problem solving is a set of skills and knowledge needed to uncover unfamiliar or unknown problems [5]. To solve this problem, it is possible to make hypotheses, or predictions, from which to propose different measures and find the optimal solutions to solve them.

Higher education in Vietnam requires reforming training curricula and teaching methods. Consequently, lecturers need to innovate teaching methods and testing and assessment methods to develop students' competency [6]. They must access research on competency development processes and measures and ways to test and evaluate students toward competency development.

In Vietnam, there have been many research authors on problem-solving teaching methods. However, the number of studies on problem-solving teaching methods to foster problem-solving competency for students is still limited. Therefore, it is necessary to have more specific studies as illustrative examples for teachers to refer to, contributing to improving teaching and learning effectiveness and meeting the goals of the new training program.

1.1 Problem-solving competency

A student's problem-solving competency is a student's ability to act based on the effective mobilization and combination of internal and external resources to solve difficulties successfullythe challenge of the problem exists concerning practice. Internal resources are students' knowledge, skills, attitudes, strategies, emotions, morals, and motivations. External resources can be teachers, experts, or community support[7].

1.2 Structure of problem-solving competency

Students' problem-solving competency demonstrates through activities in the problem-solving process. By analyzing the structure of the problem-solving, it can saw that there are four components: learn about a problem; propose solutions; implement thesolutions; evaluate problem-solving activities, detecting new problems. Each element includes some behavior when students work independently or when working in groups during problem-solving.

Table 1. Structure of problem-solving competency[8]

Elements of competency	Behavioral indicator
1. Learn aboutproblem	1.1 Learn about the problem situations
	1.2 Find out the problems
	1.3 Problem statement
2. Propose the solutions	2.1 Rephrase the situation in your own language
	2.2 Find information related to the problem
	2.3 Propose the solutions to problem-solving
3. Implement the solutions	3.1 Make a specific plan to implement the solution
	3.2 Implement the solutions
	3.3 Evaluate and adjust specific resolution steps right in the implementation process
4. Evaluate problem-solving activities, detecting new problems	4.1 Valuate the problem-solving process and adjust the problem-solving process
	4.2 Detecting new problems that need tosolve

In Physics, the problem-solving process can follow the way of reasoning (theoretical reasoning) or experimental way (observation, conducting experiments). Learning methods and forms that have many advantages in fostering problem-solving competency for students are problem-solving teaching, problem-based teaching, project teaching, etc. When using any teaching organization method, the cognitive process needs to follow the scientific process of problem-solving: problem proposition - guessing solution - theoretical/experimental investigation - test and apply the results.

1.3 Problem–solving a teaching

According to Okol, problem-solving teaching, in general, is all actions such as organizing problem situations, expressing problems, paying attention to help students with what they need. Needed to solve a problem, test that solution, and finally lead the process of systematizing and consolidating acquired knowledge[9]. Problem-solving teaching is a teaching style that teaches students the habit of exploring and solving problems in the way of scientists, creating needs and interest in learning, helping students acquire knowledge, and developing students' competency.

1.4 Problem-solving teaching process

This method needs to establish a diagram to simulate the scientific process of problem-solving. Building the knowledge to be taught will create the necessary scientific basis for thinking, determining the teaching objectives, learning, and finding ways to organize problem situations, orienting activities to explore and solve students' problems in the learning process, and acquiring new knowledge. The presentation of the simulation diagram should show the following factors: the situation where the problem arises; problem; solution orientation for the problem posed; results/conclusions about new knowledge.

II. Research Methods

The article uses the literature review on problem-solving competency, problem-solving capacity structure, problem-solving teaching, and the problem-solving teaching process. Then, establishing a scientific process of building knowledge in teaching some contents of Nuclear Physics for Food Technology students, including content 1. Ionizing radiation; content 2: Radiation dose; content 3: Biological effects of ionizing radiation; content 4: Application of ionizing radiation in students' majors.

III. Result

3.1 Establishing a diagram of the scientific process of building content 1: Ionizing radiation

+ *Objectives*: to help students understand ionizing radiation and the mechanism of action of ionizing radiation on matter.

+ *Learning outcomes*: After studying this content, students will be able to:

- State the concept of ionizing radiation;
- Explain the mechanism of action of ionizing radiation when entering the material medium.

Table 2. Diagram of thescientific process of building knowledge content 1: Ionizing radiation

1. The problem arises from the situation: Astronauts (NASA) can use foods such as meat, fresh milk ... which have been sterilized by irradiating the food with ionizing radiations → topreserve food longer.

⇩

2. Problem statement*:* What is ionizing radiation? Why can they use ionizing radiation to preserve food?

⇩

3. Problem-solving*:* Propose the solutions to problem-solving: understanding and analyzing documents to find answers.
From learned knowledge: There are types of radioactive rays: alpha, beta, gamma emitted from radioactive substances and have different penetrating abilities → When passing through the material medium, the particles of radioactive rays are all similar interaction with the atoms of that matter to change the properties of the environment → radioactive rays lose energy → causing ionization.
When irradiating food with ionizing radiation, → changes the DNA in bacteria (insects) residing on food, causing genetic defects. Bacteria will die if they can't repair these defects or duplicate themselves → topreserve food for longer.

⇩

4. Conclusions
- Ionizing radiation is radiation with enough energy to cut chemical bonds, knock electrons out of atoms, creating highly reactive ions.
- Ionizing radiation passes through a material medium, causing that medium to ionize and change the chemical structure of material objects in that environment, possibly causing mutations in molecular DNA, causing direct or indirect damage to cells, bacteria, viruses.

3.2 Establishing a diagram of the scientific process of building content 2: Radiation dose

+ *Objectives*: to help students understand radiation doses
+ *Learning outcomes*: After studying this content, students will be able to:
  - Find out the problem and propose the solution to problem-solving.
  - State and distinguish the concept of absorbed dose, exposure dose, equivalent dose, effective dose; write down the relevant formulas for each radiation dose and memorize their units.

Table 3. Diagram of thescientific process of building knowledge content 2: Radiation dose

1. The problem arises from the situation: To effectively kill bacteria and pathogenic microorganisms on food without affecting the nutritional value of food, people must irradiate food with ionizing radiation; both cause damage to food bacteria and microorganisms.

⇩

2. Problem statement*:* Does irradiating any ionizing radiation such as X-rays and gamma rays into the general physical environment cause the same damage?

⇩

3. Problem-solving: Propose the solutions to problem-solving: learn and analyze documents to find answers.
+ The changes occurring in the physical environment in general when irradiated all depend on the absorbed radiation energy, the number of charges generated in the ionization process→ the damage caused are different.
A number of radioactive rays leave a radioactive source. Under the effect of radioactive rays (X-rays, gamma rays), the total number of charges of the same sign generated in a unit mass of the irradiated medium is → of the radiation dose.
+ A quantity of radioactive rays enters the material medium to be irradiated. Under the action of radiation, the energy of radiation absorbed in a unit mass of the irradiated medium is → of the absorbed dose.
+ A quantity of radioactive rays enters the material medium to be irradiated. Under the action of different radioactive rays, the energy of radiation absorbed in a unit mass of the irradiated medium is different by → the equivalent dose.
+ A different number of radioactive rays enter the material environment to be irradiated. Under the action of different radioactive rays, the energy of radiation absorbed in a unit mass of the irradiated medium is different → from the effective dose.

⇩

4. Conclusions
- Absorbed doseD_h is a physical quantity indicating the energy of radiation absorbed per unit mass of the irradiated medium:$D_h = \frac{\Delta E}{\Delta m}$
In the SI system, the unit of measurement of absorbed dose J/kg is called the Gray (Gy).
- Irradiation does: Applies only to electromagnetic wave radiations (X-rays and gamma rays), indicating the number of charges of the same sign of ions produced in a unit mass of dry air under the action of X-rays or

gamma.SI rays, single.
$D_c = \frac{\Delta Q}{\Delta m}$ where ΔQ is the total number of charges of the same sign produced in the mass Δm
In the SI system, the unit of measurement of the dose is C/kg. The legal team is the Roentgen (R).
- Equivalent dose: At the same absorbed dose, different types of radiation cause different lesions, so: Equivalent dose = Absorbed dose x Q with Q being the ray quality factor. In the SI system, the unit of equivalent dosimetry is the Sievert (Sv).
- Effective dose: Different tissues receiving the same equivalent dose have different biological damage, so: Effective dose = Equivalent dose x W where W is the radiosensitivity of the tissues. In the SI system, the unit of adequate dosimetry is the Sievert (Sv).

3.3 Establishing a diagram of the scientific process of building content 3: Biological effects of ionizing radiation

+ *Objectives*: equip students with knowledge about the biological effects of ionizing radiation
+ *Learning outcomes*: After studying this content, students will be able to:
   - Discover the problem and guess the solution to the problem.
   - Understand the mechanism of action of ionization on living organisms, the effect of ionization on cells**.**

Table 4. Diagram of the scientific process of building knowledge content 3: Biological effects of ionizing radiation

1. The problem arises from the situation: Different tissues receive the same equivalent dose but have other biological damage. Some lesions appear early, but some lesions come very late.

⇩

2. Problem statement: What factors will biological damage appear sooner or later?

⇩

3. Problem-solving: Propose the solutions to problem-solving: understanding and analyzing documents to find answers.
+ The sensitivity of living organisms to ionizing radiation and the ability to recover from irradiation is not the same → as different lesions appear.
+ If irradiated with high doses for a short time, → it affects the central nervous system, blood, hematopoietic organs, digestive system, skin, sex organs, and embryonic development.
+ If irradiated with a low dose for a long time, → it affects life expectancy, cataracts, a higher probability of cancer, genetic mutations.
+ Under the effect of ionizing radiation, cells can fall into the following state: - Death due to severe damage to the nucleus and protoplasm. Stops division due to damage to genetic material. - Cells cannot divide, but the number of chromosomes still doubles and becomes a giant cell. - Cells divide into two new cells, but there is a disorder in the genetic mechanism.

⇩

4. Conclusions
- Ionizing radiation acting on living organisms will cause damage and effects that disrupt their physiological functions.
Early damage usually occurs when the body is exposed to high doses for a short time.
- Late effects are common in people with low and chronic radiation exposure due to occupations with frequent radiation exposure.
- Young cells that are maturing, rapidly increasing, and easy to divide often have high radiosensitivity. Cancer cells have a robust reproductive ability and poor differentiation, so they are more sensitive than surrounding healthy cells.

3.4 Establishing a diagram of the scientific process of building content 4: Application of ionizing radiation in students' majors

+ *Objectives*: equip students with knowledge about the application of ionizing radiation in students' majors
+ *Learning outcomes*: After studying this content, students will be able to:
   - Describe food irradiation technology
   - Identify signs of irradiated products
   - Explain the mechanism of action, irradiation dose, and safety of food irradiation

Table 5. Diagram of the scientific process of building knowledge content 4: Application of ionizing radiation in students' majors

1. The problem arises from the situation: The United Nations Food and Agriculture Organization (FAO for short) estimates that around 25% of total food production worldwide is lost after harvesting due to insects, bacteria, and spoilage.Furthermore, in a globalized economy, food products must meet high quality and quarantine standards to be able to be exported across borders. → One of the effective measures to meet current standards is food irradiation technology.

⇩

2. Problem statement: What is special about food irradiation technology? What are signs to identify irradiated products? What are the mechanism of action, irradiation dose, and safety of food irradiation?

⇩

3. Problem-solving: Propose the solutions to problem-solving: understanding and analyzing documents to find answers.

+ To meet quality and quarantine standards it is necessary to eliminate or inhibit the growth of harmful insects and microorganisms that reside on food → use appropriate ionizing radiation to destroy food. food management.

Advantages of food irradiation technology:

- Create a safe food source because it does not meet radioactive sources, so it is not radioactive
- Do not appear any toxins on food that are harmful to humans
- The process of interaction generates negligible heat → does not affect the nutritional value of food.

+ On the product, many stamps are indicating different purposes, the sign to identify irradiated food is the symbol called Radura.

+ Because ionizing radiation on different foods will cause different injuries, depending on the purpose of irradiation, a reasonable dose of radiation should be used.

- Implementation of the solution:

+ Setting up the actual irradiation process with steps on a specific agricultural product (fruits, dry goods, cereals...) is conducted at the Irradiation Center of Ho Chi Minh City.

⇩

4. Conclusions

Food irradiation is a technology to control spoilage and remove pathogens from food.

- Purpose of irradiation: Preventing food causing disease, preserving, controlling insects, inhibiting germination, and ripening process, sterilizing food.
- On products stamped with the international symbol with the name Radura in accordance with FDA regulations "treated with radiation".
- Different foods will require different dosages.
- Safety of irradiation: does not affect the nutritional value of food, does not contaminate food.

IV. Conclusion

To meet the learning outcomes in the training program, lecturers need to change how they teach and learn comprehensively. Based on the literature review, the article presented a scientific process of building knowledge in the style of problem-solving teaching in some contents of Nuclear Physics.The design of the scientific process has shown that to help students master the basic knowledge and skills of Physics and develop problem-solving skills. Teachers need to organize and orient students to practice forms of action. Students will know what they will achieve, what they can do, the level they need to succeed, and the know-how to connect the knowledge and skills of the subjects, contributing to improving the quality of learning and training.

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