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Integrated Teaching Oriented Toward Developing Problem-Solving Competence For High School Students

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Abstract
The article focuses on developing an integrated teaching theme in Grade 12 Physics to foster students' problem-solving competence, based on the content strand of nuclear physics. The study employs theoretical research methods, analyzing theoretical foundations related to the concepts of integration and integrated teaching, while also examining the manifestations of problem-solving competence specified in the General Education Curriculum. On this basis, the authors propose the integrated theme "Irradiated Food" *oriented toward the development of students' problem-solving competence. The findings indicate that an integrated teaching theme aimed at developing students' problem-solving competence consists of multiple components and is implemented through different stages. Therefore, teachers need the ability to analyze content strands, propose instructional ideas, and connect them into specific learning tasks in order to organize effective teaching*
Keywords: *Integrated teaching, competence, theme, physics, students*

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I. Introduction

The trends and outcomes of integrated teaching have been exerting positive impacts on teaching and learning activities in secondary schools and are considered one of the most effective approaches to developing students' competencies, particularly the competence to apply acquired knowledge to solving real-life problems (Nguyen et al., 2025). Integrated teaching is a pedagogical approach in which learners are required to mobilize various resources to address complex, problem-based situations in order to develop their competencies and personal qualities (Do, 2015). Such complex situations are governed by principles related to multiple scientific fields rather than being confined to a single subject area (Pham & Nguyen, 2019). In natural science subjects, the organization of integrated teaching enables students to explore and understand the applications of learned knowledge in everyday life (Pham, 2014). Essentially, integrated teaching involves the integration of objectives, content, organizational forms, methods, teaching aids, techniques, as well as assessment and evaluation in the teaching process as a whole (Do et al., 2023).

Integrated teaching is one of the major trends in current educational reform, supporting learners in effectively accomplishing learning tasks and thereby fostering the formation and development of concepts, knowledge, skills, and essential practical competencies (Dung, 2025). To implement integrated teaching, teachers are required to design integrated lesson plans, which in turn necessitate the identification and development of integrated themes (Mai et al., 2022). Survey results on teachers' awareness and the current practice of organizing natural science teaching at the lower secondary level indicate that teachers are facing considerable difficulties in implementing integrated teaching. These difficulties include a lack of confidence in identifying relevant natural science knowledge, analyzing curricula, designing lesson plans, and organizing integrated thematic instruction in schools (Nguyen & Do, 2024).

Based on the above analysis, we argue that integrated teaching represents a feasible and appropriate solution for developing students' problem-solving competence. Accordingly, this article seeks to address the following research questions: (i) What structure should an integrated teaching theme in Physics have in order to develop students' problem-solving competence? and (ii) To what extent can an integrated teaching theme designed according to this structure be effectively used to develop students' problem-solving competence?

II. Research Content

To determine the structure of an integrated teaching theme in Physics at the high school level, it is first necessary to clarify the concepts of integration, integrated teaching, and the process of developing integrated teaching themes in schools based on previous studies. Based on these conceptual foundations, we propose a general structure for an integrated theme and present an illustrative example of this structure through the theme *"Irradiated Food."* Since the objective of integrated thematic teaching is to develop students' competencies, it is essential to assign challenging tasks (Wang & Hazari, 2018). In addition, we develop an assessment rubric to

evaluate students based on specific observable indicators. The competence fostered through this theme consists of the components of problem-solving competence as defined in the General Education Curriculum.

The Concept of Integrated Teaching

According to Do Huong Tra, integrated teaching is the act of organically and systematically connecting the objects of study and learning from several different subject areas into a unified body of content, based on theoretical and practical relationships addressed in those subjects, with the aim of developing essential

Steps for Developing an Integrated Teaching Theme

Nguyen Van Bien proposes seven steps for developing an interdisciplinary integrated teaching theme, including: selecting the theme; identifying the issues (questions) to be addressed within the theme; determining the knowledge required to resolve these issues; formulating the teaching objectives of the theme; designing the content of the theme's teaching and learning activities; developing the teaching plan for the theme; and organizing instruction and assessing the theme (Nguyen, 2015).

According to Mai The Hung Anh, Phan Duc Duy, and Phan Thi Thanh Hoi, the process of designing an integrated thematic teaching plan consists of five steps and involves two main phases: identifying and developing the integrated theme. Based on the existing content strands, the authors proceed to design a detailed teaching plan (Figure 1).

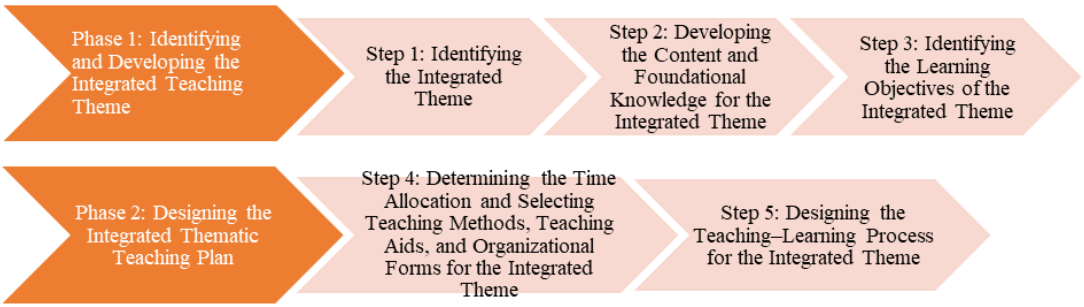

Figure 1. Process for Designing an Integrated Theme (Mai et al., 2022)

To develop an integrated theme oriented toward students' competency development, teachers, in addition to identifying objectives and content, need to design a competency assessment rubric. This rubric should be developed based on clear criteria, be reliable, and be measurable. In our view, an integrated theme must ensure that its content is closely connected to real-life contexts; therefore, integrated themes serve as an effective means for forming and developing problem-solving competence among high school students.

III. Results And Discussion

Structure of the Integrated Theme

Based on the analysis of the theoretical foundations of integrated teaching, we propose a structure for an integrated theme comprising the following components:

a. Theme objectives: The overall objectives of the theme and the expected learning outcomes as specified in the General Education Curriculum.

b. Pedagogical idea of the theme: This component clarifies how the contents of the integrated theme are connected to real-life contexts, originating from contemporary issues. These issues should be closely related to the topics covered in the high school Physics curriculum.

c. Teaching–learning process graph of the integrated theme: Based on a competency-oriented teaching and learning process, each theme is developed in a specific manner. The graph serves as a concise description of the instructional content, organized according to the chronological sequence of classroom teaching activities.

d. Selection of instructional organization forms: Each phase of the teaching process contributes to the development of specific component competencies; therefore, different instructional organization forms are required. The selection of appropriate organizational forms enables teachers to provide clear guidance and actively manage teaching and learning activities.

e. Detailed teaching–learning process: This component provides a detailed description of each instructional activity, with component competencies identified according to each phase of the process. Teachers use this progression to observe and assess students' development, serving as a basis for the effective use of competency assessment rubrics. During instruction, if students encounter difficulties, teachers may provide guidance through information sheets.

f. Design of a problem-solving competence assessment rubric for students.

Development of the Integrated Teaching Theme "Food Irradiation"

a. Learning objectives of the theme

General objective: To study the method of using gamma radiation for the preservation of exported food products.

Expected learning outcomes: Students are able to briefly describe the properties of gamma radiation.

b. Pedagogical idea

One of the most important applications of research on radioactive phenomena lies in the properties of different types of radiation. In addition to its role in cancer treatment, gamma radiation has many other applications in agriculture, forestry, and fisheries. At present, the widespread situation of "rescuing" agricultural products has occurred in many places; according to scientific analyses, this is largely due to the fact that these products cannot be exported because developed countries impose very high technical barriers. This theme helps to integrate knowledge from three disciplines - Physics, Chemistry, and Biology. Students not only learn about radioactive radiation but also understand its effects and its use in sterilizing exported fruits. Through this integrated knowledge, students can perceive the interconnections among different scientific fields within a common real-world context.

c. Graph of the thematic teaching content

We analyze the content of the theme *"Food Irradiation,"* which applies knowledge from the Grade 12 Nuclear Physics unit to real-life contexts. The theme focuses on a specific "branch" of radiation, including gamma rays, alpha particles, and both positive and negative beta particles. In the current textbook, this content is only briefly introduced and has not yet been examined in depth in classroom instruction. Therefore, we represent the content in the form of a structural diagram consisting of four main content strands: learning questions, information to be synthesized regarding the application of radiation in food irradiation, evaluations of advantages and disadvantages, and finally, conclusions (Figure 2).

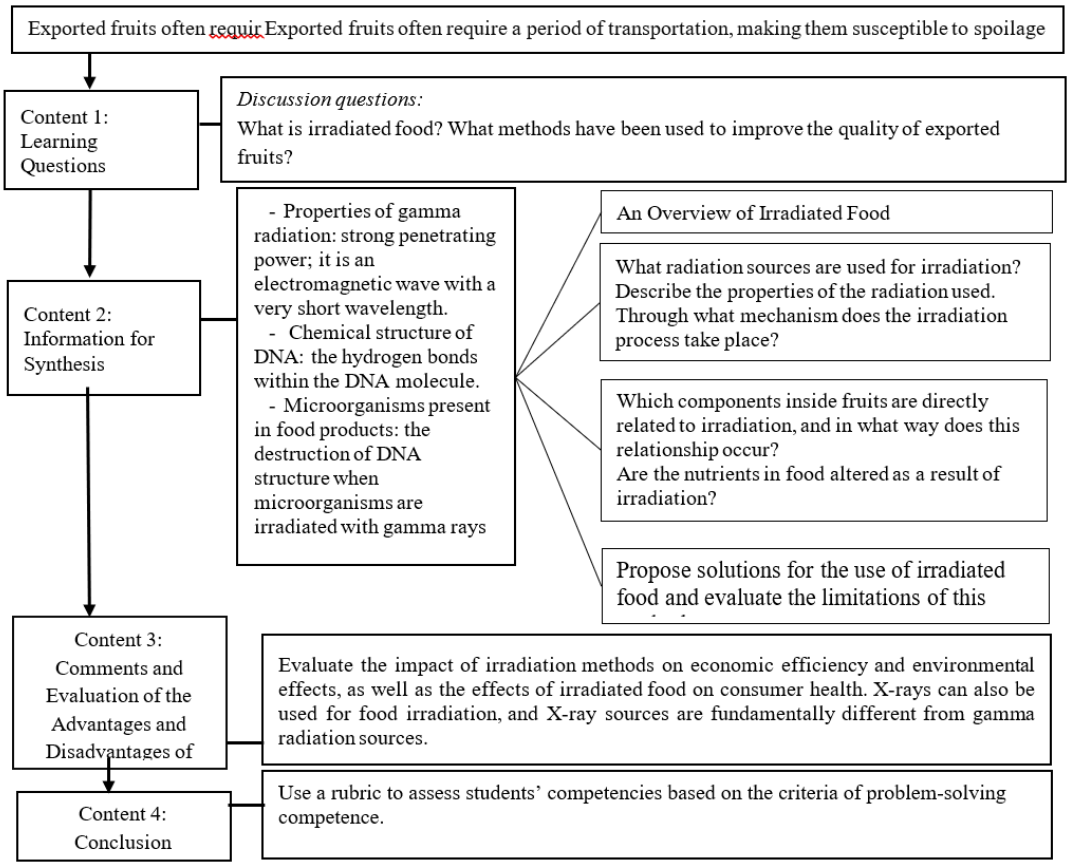

Figure 2. Graph of the Teaching Process for the Food Irradiation Theme

d. Selection of instructional organization forms

We propose organizing the integrated teaching theme through lectures, group work, and student presentations.

e. Teaching–learning process

Activity 1. Introducing the theme and identifying the learning questions

Objectives:
- Students observe, reflect, and orient themselves toward identifying issues presented in the teacher's introduction.
- To motivate students, fostering interest and engagement in the teacher's theme.
- To generate learning questions.

Detailed description of the teaching plan:

The teacher invites students to observe an image (Figure 3). The rationale for using this image is that it contains the Radura symbol, an international symbol used to identify food products (especially fruits) that have been irradiated for preservation and for the elimination of harmful microorganisms.

Figure 3. Fruits and the Radura Symbol
Source: https://www.linkedin.com/pulse/all-you-need-know-irradiation-food-products-anil-mathew-varghese

(Students are asked to discuss and make predictions related to the theme.)
Teacher: Based on the images above, what issues do they make you think of? Why?
Students: Observe, reflect, exchange ideas within their groups, and then a group representative presents their opinions.

Possible student responses may include:
Opinion 1: The food is contaminated with radiation.
Opinion 2: The fruits are radioactive.
Opinion 3: Irradiated food, because I recognize the Radura symbol that I have read about or seen on television.
Teacher: These are irradiated food products. Should we consume such food? Please discuss this question within your groups for five minutes and record your group's opinions.
The teacher distributes group work sheets (Figure 4).

Student's full name:
1. …… 2) …… 3) ……
In your opinion, should we consume irradiated food? Why or why not?

Figure 4. Content of the Group Opinion Discussion Sheet

The teacher invites one student to present the group's opinion and may ask the student to read the group's answer sheet aloud for the whole class.

Teacher: The teacher acknowledges the groups' opinions. The answers may vary greatly, and there are three possible cases.

-For students who have no real-life knowledge, this topic is completely new. They may choose an answer at random but are unable to explain the reason for their choice.

-For students who have some background knowledge and have learned about this issue from documents or news sources, they may choose to eat the food because it has been approved as safe.

-For students who have both background knowledge and practical experience, they may believe that the food should be consumed, but certain aspects such as packaging, labeling, and irradiation dosage need to be considered.

Teacher: The teacher asks students to look at images of irradiated products sold in supermarkets and further explains the symbol on the packaging: a green circle containing a shape similar to a leaf or a sprout, usually with a semicircle or lines above it representing radiation rays (Figure 5).

Figure 5. Packaged irradiated fruits and food products.
Source: https://www.researchgate.net/figure/The-Radura-symbol-Figure-2-Labeling-irradiated-foods-Source_fig1_259717514

The issue we are going to discuss today is related to the new lesson content, namely irradiated food. To determine whether it should be consumed and why, what issues do you think we need to explore? Students discuss and write down the issues that need to be explored about the topic on the worksheet (Figure 6).

Student's full name:

1. …….. 2) …….. 3) ……..

Please write down the issues that need to be clarified in this topic (What knowledge is this topic related to?

For example: What materials are used for irradiation?

Figure 6. A worksheet asking students to identify questions related to the topic of irradiated food.

The teacher collects the worksheets and reaches agreement on the issues proposed by the students for investigation, while also adding further ideas to make the content more complete.

Activity 2: Exploring issues related to the questions
Objective: To investigate and form new knowledge on *the properties of gamma radiation*.
The teacher guides students to explore and answer the following questions:
*Question 1***.** What is food irradiation? How can irradiated food be identified?
Question 2. In Vietnam, which type of radiation is used to irradiate dragon fruit for export? What is the source of this radiation?
Question 3. Describe the mechanism of radioactive rays or ionizing radiation. Why can they eliminate bacteria while still preserving the nutritional value of food?
Question 4. Evaluate the limitations of this method.

Activity 3: Synthesizing data to provide answers
Objective: To connect knowledge and provide answers by explaining, based on scientific evidence, how irradiation helps food last longer while maintaining its quality.
- Irradiated fruit is one of the solutions to ensure quality during export. It can be identified by the Radura symbol on the product.
- The sources used for irradiation are the isotopes Cobalt-60 or Cesium-137, which emit gamma rays. In addition, X-ray radiation can also be used.
- Because the hydrogen bonds in bacterial DNA can be broken by gamma radiation with strong penetrating power, bacteria are unable to reproduce in the fruit, and sprouting is also inhibited. Gamma rays act directly on DNA, which determines genetic characteristics, preventing cell division. Furthermore, gamma radiation can induce DNA mutations by inserting or deleting DNA sequences.
- Limitations: High cost and the potential risk of environmental pollution if radiation safety principles are not properly followed.

Activity 4: Presenting the research findings
Objective: To develop the ability to reason and accurately use scientific terminology; gamma rays have strong penetrating power and are produced from radioactive sources such as Cobalt-60 and Cesium-137.
Evaluate the impact of the irradiation method on environmental, economic, and health-related aspects.
Students present their reports using PowerPoint presentations or posters.

Activity 5: Conclusion and knowledge consolidation
Students' competencies are assessed using a rubric, as shown in Table 2.
The teacher reinforces and summarizes the key content of the topic.

f. Developing the assessment rubric

Based on the general school curriculum, we propose a set of criteria for assessing students' problem-solving competence, as presented in Table 1.

Table 1. Criteria for assessing students' problem-solving competence in the topic *"Irradiated Food"*.

Performance indicators	Level
- Able to analyze the situation in the introductory part of the lesson by observing the illustrative image related to irradiated food and radioactive nuclei, and identify and state a problematic situation (competency code A1). - Able to raise multiple meaningful questions in response to the teacher's guiding question about which issues need to be explored in order to decide whether irradiated food should be consumed (competency code A2).	

- Able to clarify information about the origin of irradiated food (from gamma rays—a product of radioactive decay, such as that from the isotope Cobalt-60) using different information sources, such as internet access and teacher-provided worksheets (competency code A3). - Able to collect and clarify information related to the issue, including investigating the potential effects of gamma rays on DNA and their inhibitory effects on the growth of fungi and bacteria (competency code A4). - Able to generate multiple new ideas, such as proposing the use of irradiated food for export or to support poorer countries, and demonstrate non-linear thinking by challenging the assumption that all irradiation-related issues are harmful to human health (competency code A5). - Able to develop and connect ideas about gamma rays, which are the highest-energy form of radiation in the electromagnetic spectrum, and recognize that, when used within dosage limits permitted by the Food and Agriculture Organization (FAO), they can serve as an effective solution to limit the spread of agricultural diseases while maintaining the nutritional quality and flavor of food (competency code A6). - Able to assess risks and propose precautions, recognizing that building gamma-ray irradiation facilities involves high costs and may pose risks of environmental pollution (competency code A7). - Able to attend to logical arguments and convincing evidence, and be willing to reconsider and re-evaluate the issue, recognizing that the application of gamma rays in agriculture and food irradiation is feasible and an inevitable trend in the context of global integration (competency code A8).	

Description of competency levels:
*Level 1***:** No competence.
Level 2: Competence at a basic level (able to complete the task but requires support).
Level 3: Competence at a good level (able to complete the task independently but with some errors that need adjustment).
Level 4: High-level competence (able to complete the task independently with very few errors or completely correctly).

Teachers need to analyze and propose ideas for teaching through integrated themes in order to develop students' competencies. Although the topic has been designed to foster both physics competence and general competencies, there remain limitations, particularly the insufficient integration and specification of learning outcomes within the topic. As a result, teachers may need a considerable amount of class time to implement it. Therefore, the topic may be more suitable for use in extracurricular lessons or advanced activities to help students better understand and apply knowledge in real-life contexts.

IV. Conclusion

The article has presented issues related to integration and integrated teaching. Based on the synthesized theoretical framework, we propose a structure for integrated teaching themes. Accordingly, teachers should analyze the topics and lessons in the general education curriculum, select and propose appropriate themes that help students develop activeness, independence, and the ability to apply integrated knowledge to real-life situations. Developing a content graph and a teaching process enables teachers to organize classroom instruction more effectively. It should be noted that integrated teaching also encourages students to pay greater attention to scientific concepts and terminology in each subject, to connect them, and to use them in specific contexts. In our view, integrated themes have the potential to develop higher-order thinking skills in students, such as analysis, comparison, synthesis, and problem-solving, rather than learning isolated pieces of knowledge. As a result, students are more likely to recognize the relevance of and develop a greater interest in science subjects at school.

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