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TRAINING PRE-SERVICE TEACHER COMPETENCE TO INTEGRATE INTERDISCIPLINARY KNOWLEDGE TO SOLVE PROBLEMS IN PRACTICE THROUGH THE INTEGRATED TOPIC IN GENERAL PHYSICS MODULE

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Abstract. In higher education, it is essential to change teaching method toward the learner-centered orientation. Teaching through topics with practical content is one of the preferred options today. Problems in real-life contain complex elements that are almost impossible to explain by just one subject. The paper presents the method of organizing thematic teaching to foster pedagogical students' ability to integrate interdisciplinary knowledge so that they can explain practical problems based on evidence and scientific foundations in the General Physics teaching process.

Keywords: Pedagogical student, interdisciplinary integration, topic, general physics.

1. Introduction

Integrated teaching is a teaching method that focuses on the formation, development of creative thinking and general skills through cohesion and coordination of close related content, to form in students the capacity to solve problems, especially diverse issues of practical situations [1].

Tra D.H (2015) studies the approach of interdisciplinary integrated training to pedagogical students. The research indicates that it is important to train students with interdisciplinary integrated teaching competence, and it is important to train students in the form of interdisciplinary integration. Accordingly, there are four approaches to teach students as follows [2]:

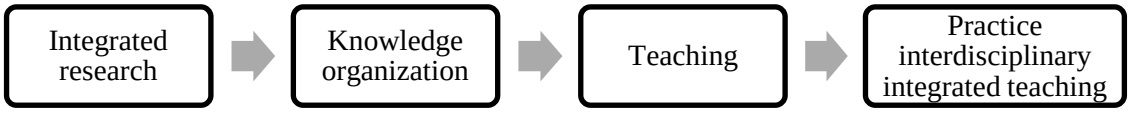

Figure 1. Tra D.H (2015)'s model: Four interdisciplinary integrated approaches to pedagogical students

Integrated teaching is possible in the first yearof university study. Hai, T.D. (2016)'s proposal is to divide the capacity-building work for pedagogical students into several stages and it begins with the general subjects by interdisciplinary integrated projects [3].

According to the authors Phu P T. and Thuoc N D (2019), integrated pedagogical thought includes the followings [4]:

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- Connecting learning and practice, theory and practice, integrating the school world with the world of life.

- Develop learning capacity, especially the basic and necessary competencies to apply and solve meaningful situations in life or as a basis for the next learning process.

- Make the most of the learner's experience as well as establish the relationship between knowledge, skills and cognitive methods of the subjects.

Topical teaching is aimed at positive and important education for the long-term development of individuals [5]. Que X. Pham (2016) proposes specific competencies includingfive skills that learners must acquire after completing an integrated topic: skills to approach problems from different opinions, skills to identify problems to be solved, analytical skills, synthesis and critical thinking. Additionally, there are specific groups of competencies for Physics including competencies related to Physics knowledge, Cognitive Physics, Communication in Physics and Evaluation [6]. Robin, Fogarty (1997) states that Subject-based teaching is closely related to interdisciplinary integrated teaching. Subject-based teaching is often combined with elementary and secondary classes using group-based teaching, but this pedagogy is also important in high schools and with higher education [7]. According to [5], the topic has four important characteristics that are integrated and realistic, promoting the positive, self-creation and creativity of learners. Because the learning content is related to reality, the learning form is mainly in groups. Besides, it also demonstrates the cooperation of teachers in different subjects. Science, whether taught in specific disciplines or in an integrated way, always aims to develop both skills and knowledge. European educational researchers including Romania (University of Bucharest), London (Royal University of London), Romania (University of Antwerpen) in 2011 published *Teaching physics in Europe: Activities, Outcomes & Recommendations*. Accordingly, the part of Physics teachers' competences is that Physics teachers must have the skills to introduce students the nature and value of science, scientific thinking, and reasoning such as the use of language in science and physics, and Physics teachers must also have the capacity to promote the development of scientific knowledge by devising active teaching strategies [8, p.43].

From the above studies, we believe that teaching through the topic needs more attention, especially for teaching students of pedagogical schools. This will significantly contribute to fostering integrated knowledge, promoting practical problem-solving competence. Along with instructor modeling strategies, students will learn teaching organization method and topics through which they are also fostered by integrated teaching topics.

2. Content

2.1. Definition of teaching by topic

Subject-based teaching is a teaching model in which the content is built into meaningful topics and demonstrates interdisciplinary and interdisciplinary relationships (integrated topics), so students can develop their comprehensive ideas [5, p.181]. Integrated topics are those that cover the content of two or more subjects or areas of study. These educational contents are related to the issues that concern the society, demonstrating the synthesis of knowledge of the subjects or the above areas in solving problems in real life [9].

As a result, from the analysis of integrated topics such as functions, content, and skills formed, we have some comments as follows:

- The content of the topic is interdisciplinary: Interdisciplinary is the most prominent feature of the topic, such as understanding the theme of health, environment, and energy are all interdisciplinary issues. Topic teaching is to encourage learners to apply the knowledge of many

subjects so that they can explain phenomena, complex situations and thereby practise life skills for themselves.

- Teaching topic is a means to train learners of high levels of competence: This is a challenging issue, that is, learners must have background, dynamic and creative knowledge. High-level competencies include analysis, synthesis, evaluation, and comparison. A complex situation highlighted in the topic will create opportunities for learners to regularly brainstorm, combine individual work, group work such as information lookup, information processing, and suggestions to process of making experiments, hypotheses and conclusions.

- Topic questions are often presented in the form of broad questions: That is, the topic must be presented in the form of one or a series of open questions, motivate learning and encourage learners to participate in answering questions. In order to create interesting surprises, the question must make learners feel that they are not listeners but they must be the ones looking for answers. Facilitators should aim for some actions that compel learners to watch clips, read newsletters, write thoughts on paper, do experiments, collect other data such as books, newspapers, and consult friends to solve the problems in that open question series. That is step by step "enticing" to the attention of learners. In addition, the topic has a wide range of knowledge, covering many areas, so it is easy to implement in general physics modules (associated with high school content).

2.2 The process of teaching competence development for students through the use of integrated topics in the General Physics module

Analyzing the competency structure integrating scientific knowledge [11], we propose the process of teaching competence development for students through the use of integrated topics in the General Physics module as in Figure 2.

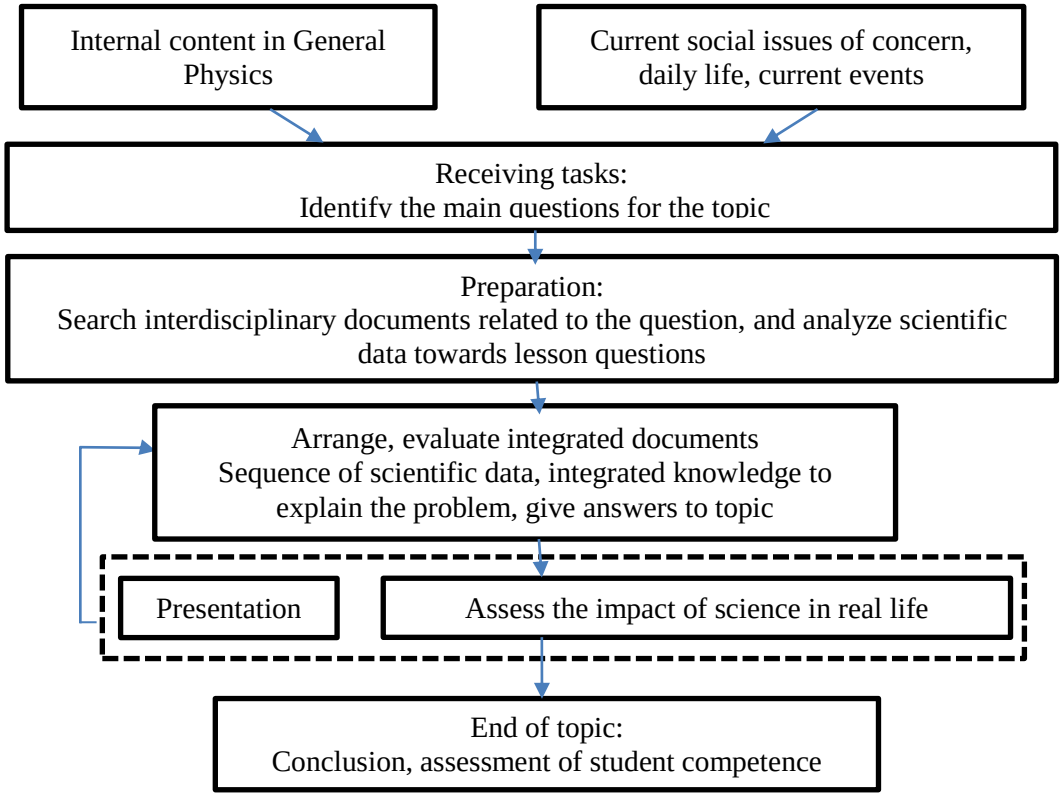

Figure 2. Teaching process access competency for pre-service teachers

Understand and identify questions around the situation: At the beginning of the teaching, teachers often set out situations, such as showing students a short clip, performing an experiment, a missing mind map, or simply using methods of conversation. There are two ways for students to accept tasks: directly and indirectly.

+ Directly: Teachers set tasks or questions, students only accept tasks (listen to questions) passively.

+ Indirect: Lecturers explain the situation, guide students to discuss to identify questions around the situation. The trainer is the one who concludes on the accuracy of the question.

In this paper, we choose the second option.

Find scientific literature and answer questions based on evidence and scientific foundations: This stage forms the self-study skills such as planning documents synthesis, division of work in groups, processing of synthesized documents so that the answers can be reached exactly. For example, for project teaching (it is mandatory that students take it in the usual time of 1-2 weeks), students must prepare materials, list, analyze and evaluate the usefulness of documents and the selection of documents that directly serve the project. Lecturers can assist in the course of performing tasks such as providing students with the necessary resources, effective procedures and risks to avoid.

Present and point out the impact of science and technology on production life: This capacity is related to the learners' competence to use scientific language and information technology. Through the reporting process, students gradually become confident in front of the class, fostering the ability to express and communicate. Besides, from scientific institutions, students can learn the effects, advantages and disadvantages of scientific achievements on life and production.

Conclusion and evaluation: is the summary of the content presented by students. Lecturers point out the advantages and limitations, legitimize the presented group content, using the criteria table to determine the level competency level achieved by students.

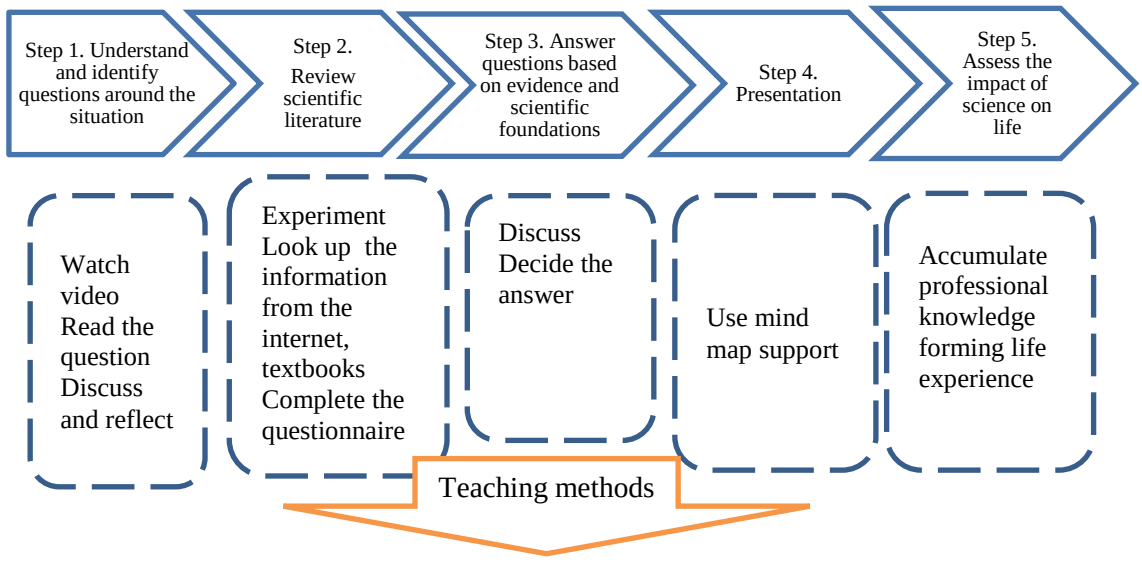

Figure 3. Integrated teaching steps and teaching methods

2.3. Findings

2.3.1. X-rays Topic and X-ray absorption salt in medicine

We propose a grap to teach X-ray topics as follows:

Detailed description of the teaching process

Activity 1. Understand and identify questions around the situation

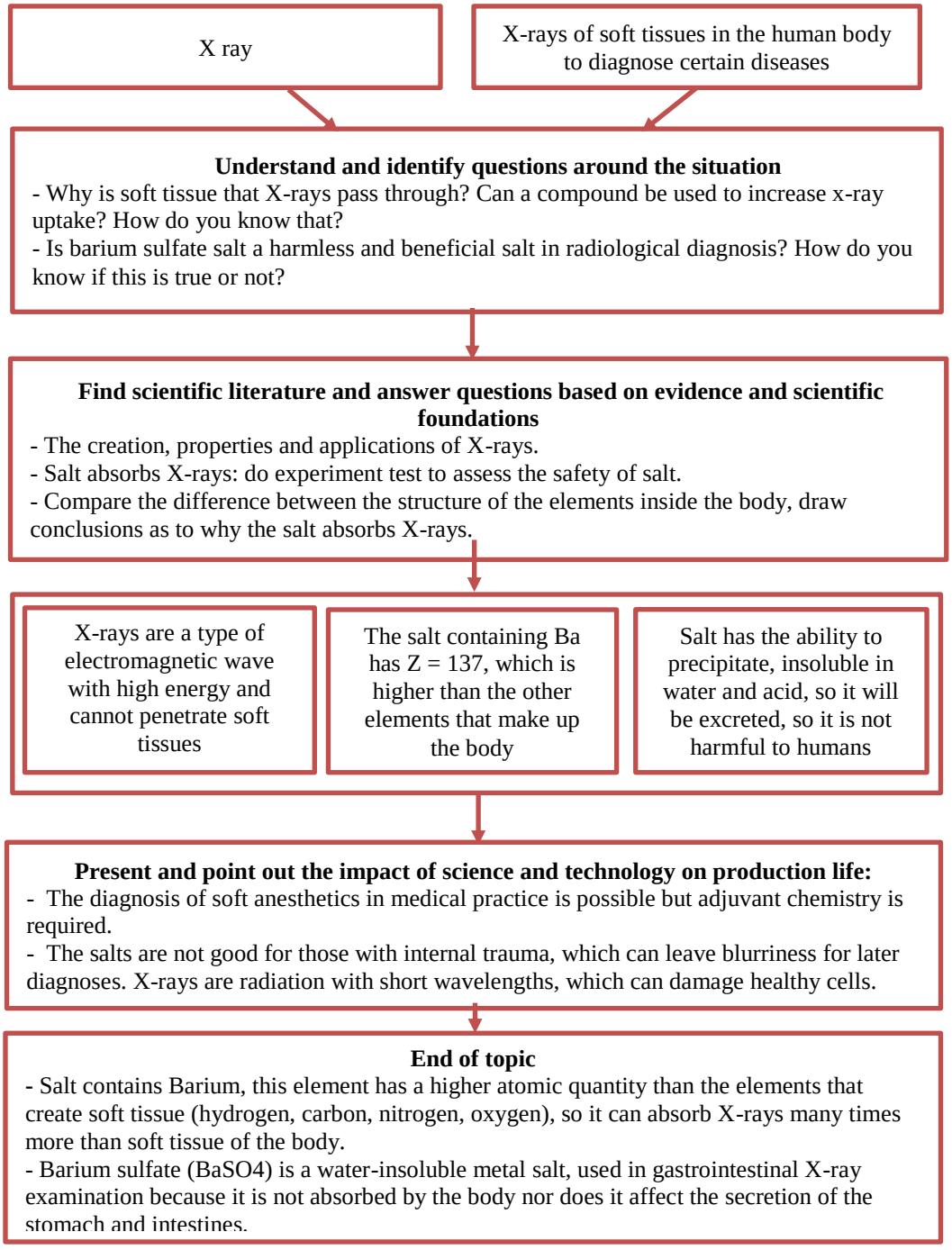

Figure 4. Grap to teach X-ray topics

Table 1. Summary of activity teaching process 1

Organized activities for students	Discuss, propose the correct solution. Complete the questionnaire around the topic.
Teaching aids	Video, questionnaire
Target	Why does soft tissue pass through the X-rays? Can a compound be used to increase X-ray uptake? How do you know that? Is barium sulfate salt a harmless and beneficial salt in radiological diagnosis? How do you know if this is true or not?

**** Detail plan***

Lecturer: Show a video of X-ray. Clip content involves taking X-rays of hard tissues such as the bones of the hands, feet, and spine: the clip does not mention shooting soft tissues.

(Source:https://www.nibib.nih.gov/science-education/science-topics/x-rays).

After finishing the video, the lecturer directed the whole class: "What do you think about X-rays when photographing parts of the human body? Please respond to your comment by choosing the correct option:

A. Currently in hospitals, X-ray technology to diagnose hard tissue injuries such as neck bones, hands, feet.

B. Currently in hospitals, X-ray technology to diagnose soft tissue lesions such as stomach and intestines.

C. Both A and B.

Teachers let students to discuss within 5 minutes, then call about 2 to 3 students to report their answer. Teacher concludes that the correct answer is C.

Student's choice may be very different, maybe A, B, C. (Predict the students who will choose A the most). So teachers prepare questionnaires to record their students.

Name: 1)……2)……3)……

The correct answer is that does C conflict with my understanding of X-rays? If I think so, where is the conflict?

……

Figure 5. Handouts to students stating unknown issues on option C

Teacher calls 1 or 2 students to speak. The teacher collects student votes, creating an opportunity for the students to ask questions about the topic.

Teacher continues by another situation: "Mr. M has stomachache, although he took medicine for a long time but does not get better. M is suspected to have a stomach tumor. To take X-rays of stomach for Mr. M, the doctor fed him a salt called Barium sulfate (BaSO4), while patient N who was in the same room with M took X-ray of bone did not need to eat this substance? Explain why?

Teacher asks students to find a series of questions about the situation. Expected questions: What are the X-ray properties? What are the properties of BaSO4 salts, and how are they related? Is barium sulfate salt a harmless and beneficial salt in radiological diagnosis? How do we know if this is true or not?

Activity 2. Finding scientific literature

Table 2. Summary of activity teaching process 2

Organized activities for students	- Draw a mind map about X-rays - Experiment with BaSO4 salt and complete learning materials - Write in the learning materials to find out the relationship between elements with large atomic number and the ability to absorb X-rays
Teaching aids	- Links provided to students to assist them in drawing the mind map. A4 blank paper. - BaSO4 salt, beaker, stirring rod. - Learning materials about experimental results. - Learning materials instructing students to find out the relationship between Z number and X-ray absorption capacity
Target	-Synthesis knowledge of X-rays: X-ray creation technique and explanation of the mechanism of operation of Cooligio machine, X-ray was discovered in 1895 by Wilhelm Rongthe, the effect of X-ray in medicine and some other areas. -Synthesis of knowledge of BaSO4: BaSO4 salt is a precipitate, insoluble in acidic environment, common elements that make up the body with low atomic masses: for example, C, N, O, H. The relationship between the X-ray resistance and the mass of the constituent element inside the body, the greater the mass, the greater the X-ray resistance.

**** Detail plan***

The teacher gives an A4 paperto each group of 3 students.

Students record documents collected and drawn in the form of thinking diagrams on A4 papers. (Supplementary information can be found at: *https://vi.wikipedia.org/wiki/Tia_X*)

Students observe and touch experimental equipment. The teacher asks the question: If you put salt in water or lemonade, what would they observe? Some students will answer the precipitate of a cup, two cups or others may not know it will say it is milky.

Students perform experiments, analyze supplementary information and record the observation results and collect them into learning materials.

Figure 6. Experimental equipment

Name: 1)…….2)…….3)……

a. Experiment with barium sulfate salt, observe and complete the learning materials.

…….....

b. Based on the information sheet, comment on the relationship between the effect of X-ray absorption on chemical elements in the body. ……

c. Tell some applications of radiology in medicine. Do radiography of the stomach affect health? Why?

Supplementary information: https://www.slideshare.net/Lanng3/to-nh-bng-tia-x

Figure 7. Handouts to students conduct experiments

2.3.3. Matrix design criteria to assess students competence

Table 3. Description of students' competency levels in teaching X-ray topics

No.	**Criteria**	**Level 1 - Below average**	**Level 2 - Average**	**Level 3 - Good**	**Level 4 - Excellent**
C.1	Understand and identify questions around the situation	Could not record question about X-ray	Ask questions about X-rays with help	Ask the question if X-rays will pass through soft tissue? But I don't know if I will ask questions about the chemicals to use as support.	Identify the correct and correct question.
C.2	Find scientific literature	Find the document but have no results. Wrong answers to questions about X-rays and BaSO4	Find some results but require help	Find some results. Answers to major physical questions but not yet combined into a complete answer.	Find the right material, accurate and practical service for integrated topic learning. Self-answer the teacher questions.
C.3	Answer questions based on evidence and scientific foundations	Unable to solve the problem: How X-rays penetrate soft tissue.	Solve the situation, but must rely on help	Solve the situation, but the explanation is not clear, know the chemical use	Solve the situation, explain very clearly, state specific scientific evidence,

				of X-ray absorption but do not know why it is absorbed.	propose experiments for testing
C.4	Presentintegrated topics in a logical, accurate and scientific manner	Expression does not make the listener understand the matter the rapporteur wants to present.	Expressions make the listener understand but not yet express the logic.	Good expression, clearly stated, but not logical, the ability to use scientific terminology is not reasonable in some sections.	Excellent expression, clear presentation, logical connection, correct scientific terminology.
C.5	Point out the impact of science and technology on production life	The harm and the advantages of using X-rays in this case cannot be assessed	Assess the harms and disadvantages but seek help	Evaluate whether X-rays cause damage to cells, but do not know how to assess BaSO4.	Comprehensive effect of radiology with soft tissue diagnosis. (X-ras and BaSO4).

2.3.4. Results of applying the topic to teach

**** Assess the level of competency for students***

We divided the class of 30 students into 10 groups. Each group consists of 3 students. The process of working in class is recorded by us. Observing and assessing behaviors, attitudes, and teamwork products are saved so that we can have a basis to evaluate the capacity of the groups.

Table 4. Competence levels of the groups

	Competence levels of the groups (G)									
	G.1	***G.2***	***G.3***	***G.4***	***G.5***	***G.6***	***G.7***	***G.8***	***G.9***	***G.10***
C.1	1	1	1	2	2	2	2	2	2	2
C.2	1	2	1	3	2	1	2	2	2	2
C.3	1	2	1	2	2	1	1	2	3	2
C.4	1	2	1	2	2	1	1	2	3	2
C.5	2	2	3	2	3	2	2	2	3	2
Average	1.2	1.8	1.4	2.2	2.2	1.4	1.6	2	2.8	2

Table 4 shows that the majority of students are at an average level. Therefore, it is necessary to have other topics to foster the capacity to increase with impact towards learning how to apply knowledge to explain practical problems. Moreover, it is also essential to

strengthen thematic teaching, designed to measure competency levels and to evaluate competency according to criteria is a feasible measure.

**** Qualitative results***

We conducted qualitative surveys with questionnaires and received the students' self-assessment results as follows:

Table 5. Self-assessment results of students

	Soaring (%)	**Increase (%)**	**Stable (%)**
Understand and identify questions around the situation	3.6	82.1	14.3
Find scientific literature	3.6	82.1	14.3
Answer questions based on evidence and scientific foundations	3.6	82.1	14.3
Give Presentation	10.7	39.3	50.0
Assess the impact of science on life	14.3	75.0	10.7

As can be seen in Table 5, students rated themselves more advanced than before, specifically 82% of students said that competence "Understand and identify questions around the situation; Finding of scientific literature; Answer questions based on evidence and scientific foundations" has increased, and 3.6% significantly increased (Soaring), only 14.3% of students said that they still felt that they had not made progress. Most of the students are still hesitant and not confident in assessing the presentation 50% of them have not improved this competence. The reason may be because they have not had many opportunities to present (Normally only representatives of groups are given chances to present.). In general, the students have had positive changes, the component competencies have been improved, and the thematic teaching method has brought very reliable results.

3. Conclusions

The paper presented the method of organizing General Physics teaching to train students the competence to integrate knowledge to solve problems on an X-ray topic. In general, students have a positive learning attitude and very interested in receiving and handling learning tasks required by the lecturer. Self-assessment results show that students' abilities have been significantly improved. Therefore, it can be concluded that subject-based teaching is a form of teaching organization that can be used to develop learners' competencies, help them gain more knowledge of physic, chemistry, and biology to teach integrated subjects after graduation.

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