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Reflective Thinking Profile of Physics Teacher Prospective Students through Nuclear Physics Learning using Virtual Laboratory

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Abstract: The virtual laboratory is a platform that helps students carry out practicum-based learning both independently and in groups. Nuclear physics is an abstract concept that discusses atomic nuclei, atomic nuclei decay, and radioactivity, which allows in practice to use virtual The purpose of this study was to determine the level of students' reflective thinking skills after using the virtual lab in the nuclear physics course. The method used is descriptive-quantitative. The data collection technique used a modified Kember reflective questionnaire with 24 statement items consisting of aspects of habitual action, understanding, reflection, and critical reflection. The research subjects were 15 prospective physics teacher students. The results showed that the levels of habitual action (72.7%), understanding (89.3%), reflection (76.9%), and critical reflection (67.87%) are all in the high category. These results explain that the profile of students' reflective thinking abilities is in the high category after learning nuclear physics using a virtual laboratory.

Keywords: Virtual Laboratory, Reflective Thinking and Nuclear Physics Learning

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INTRODUCTION

The ability to think reflectively is very rarely considered in learning, especially learning physics, even though this ability is very important for prospective physics teachers to have. Ability greatly influences student academic achievement (Ghanizadeh, 2017). Reflective thinking is conceptualized as contemplating what to do either after completing a task or while doing it. Thus, reflective thinking is useful for achieving learning targets and has a positive effect on increasing learning outcomes in groups (Hsieh & Chen, 2012). This ability is very important to train students in order to develop skills in solving problems (Ellianawati et al., 2014; Miller & Maellaro, 2016; Ramadhani et al., 2019; Yasin et al., 2020). Reflective thinking allows students to evaluate to reflect and rethink what they have learned during learning (Sinensis et al., 2019).

Reflective thinking is the ability to reflect and analyze experiences, actions and thoughts with the aim of learning and developing. For prospective physics teachers, reflective thinking is very important because it can help improve the quality of teaching and interactions with students (Hidayat, 2020). This ability also reflects the extent of further action, about how to rethink to solve problems (Sinensis et al., 2020). As a physics teacher candidate, the importance of having this ability to think reflectively is to evaluate teaching experiences, identify strengths and weaknesses, seek alternative solutions to problems (Hidajat, 2020; Manurung & Listiani, 2020). Reflective thinking requires self-awareness, a willingness to learn, and a determination to continually improve.

An understanding of core physics is needed in the world of work, for example in the mining sector (Kapugu et al., 2022). Nuclear Physics is a compulsory subject for Unuha Physics Education students whose material discusses abstract concepts. The availability of virtual laboratories allows students to study nuclear reactions, radioactivity because it is not possible to carry out these experiments directly or in real laboratories. The need for students to carry out practicum activities is a scientific process and method to accommodate students' mastery of concepts. Learning through experimentation or practicum will bring students to scientific thinking to a strong, innovative, and logical process between concepts and phenomena (Ranjan, 2017).

Higher education in the 21st century brings students to have higher-order thinking skills including the ability to think critically and think reflectively (Binkley et al., 2012; Sinensis et al., 2020). Reflective thinking skills involve the ability to link new knowledge with previous knowledge in order to reach conclusions that can be used in solving new problems. Thus, if

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students have this ability and attend training in learning physics, it will be an advantage. Students will be able to respond, evaluate, and conclude information that they understand and do not understand during the learning process.

So far, in the Unuha Physics Education Study Program, learning has emphasized the results of mastering concepts or outputs without paying attention to the process that students have or have not understood the topic of lectures. In their learning, students have not been given treatment to improve their reflective thinking skills so that students only think that somehow the most important thing is to pass the course. Reflective thinking also plays a role in providing evaluations for the students themselves and for educators (lecturers) whether what has been done so far is in accordance with the goals to be achieved. Thus in physics lectures with the help of the virtual lab in nuclear physics courses, because through the virtual lab it is seen as effective because it can be done repeatedly, can identify errors and analyzes so that it helps in increasing student reflective thinking.

METHOD

The research method uses this type of quantitative descriptive research. The data collection technique used was a modified reflective thinking questionnaire from Kember. The subjects of this study were prospective physics teachers in the 7th semester of the core course with a total of 15 students.

Reflective level analysis used a modified reflective questionnaire (Kember et al., 2008) with 24 item statements consisting of aspects; 1) habitual action, 2) understanding, 3) reflection and 4) critical reflection. For a more concise explanation of the level of reflective thinking, it can be seen in **Table 1**.

Table 1. Modified reflective thinking level

Level	Indicator	Statement Example
Habitual Action	Do activities that are often learned before (accustomed to) and are carried out automatically through conscious thought.	I'm sure if I often practice working on physics practice questions, then one day if I encounter a similar problem I can easily solve it and do it well.
Understanding	Making use of existing knowledge, without trying to judge that knowledge and learning remains within a pre-existing scheme or perspective.	In my opinion, mastering well the physics concepts conveyed by lecturers is very important in lectures
Reflective	Criticize assumptions about content or problem-solving processes	In my opinion, mastering well the physics concepts conveyed by lecturers is very important in lectures
Ciritical Reflective	Critically review the presuppositions of previous	I hope that at the end of this course it will not make me change

Level	Indicator	Statement Example
	learning both consciously and unconsciously	my perspective on myself in understanding concepts.

The questionnaire was made with the categories of agreement/disagree, namely strongly agree (SS), agree (S), disagree (TS) and strongly disagree (STS). The percentage of the number of respondents in a response can be determined using **Equation 1**.

$$PR(\%) = \frac{JSR}{SI} X\ 100\% \qquad \dots (1)$$

PR (%) = The percentage of respondents to a response, JSR is the total score of respondents' answers in a response. SI is the ideal score in a response. The ideal score is the maximum score multiplied by the total number of respondents. The criteria for the number of respondents to a response according to Riduwan (2012) can be known as in **Table 2**.

Table 2. Respondent Percentage Category for a Response

Percentage	Criteria
≤80 %- 100%	Very High
≤ 60% - < 80%	High
≤ 40% - < 60%	Enough
≤ 20% - < 40%	Low
0% - < 20%	Very Low

The virtual laboratory used in nuclear physics course is phet simulation and ck.12. The virtual lab can be accessed free of charge by students and used for learning, not only practicum simulations but there are practice questions that students can work on**. Figure 1**, **Figure 2**, **Figure 3**, and **Figure 4** are some of the virtual labs used in nuclear physics learning.

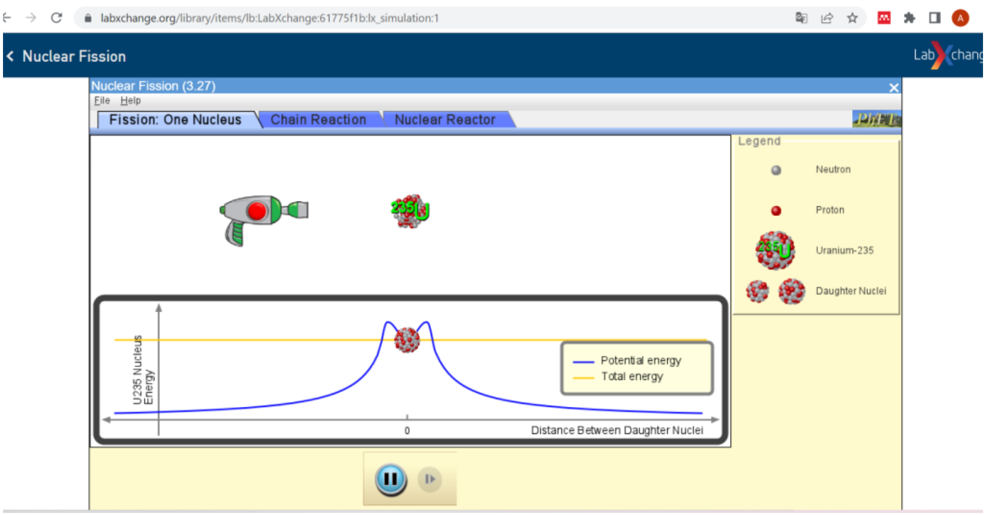

Figure 1. Phet simulation Nuclear Fission

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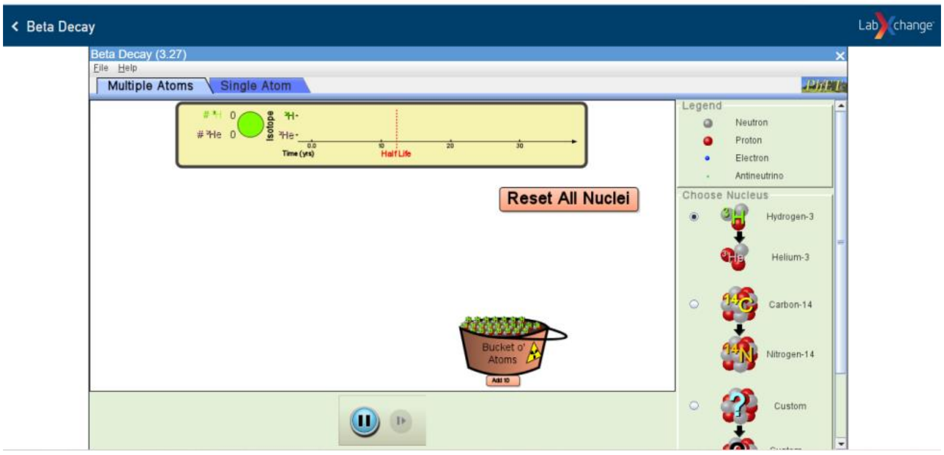

Figure 2. Phet Simulation Beta Decay

Phet simulation can be obtained via the web https://www.labxchange.org/ is a platform developed by Harvard University. This site provides various virtual laboratories in various disciplines, including physics. You can explore virtual physics experiments, take part in interactive simulations, and understand physics concepts through the guides provided.

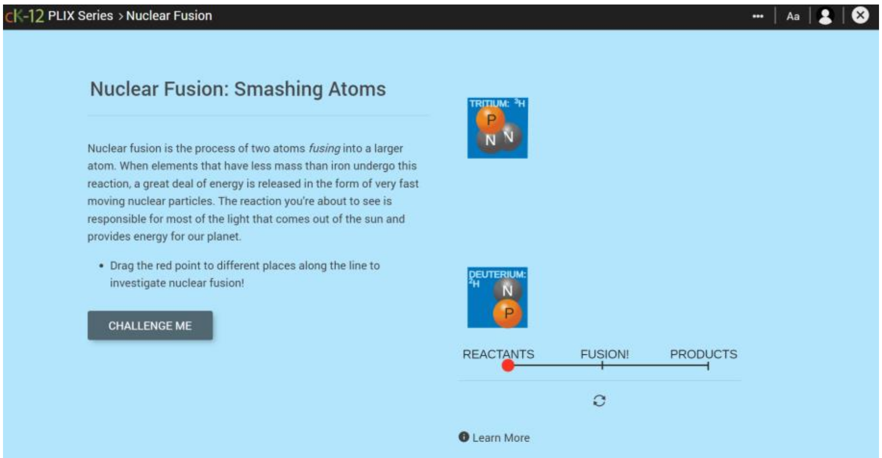

Figure 3. CK. 12 Nuclear Fusion

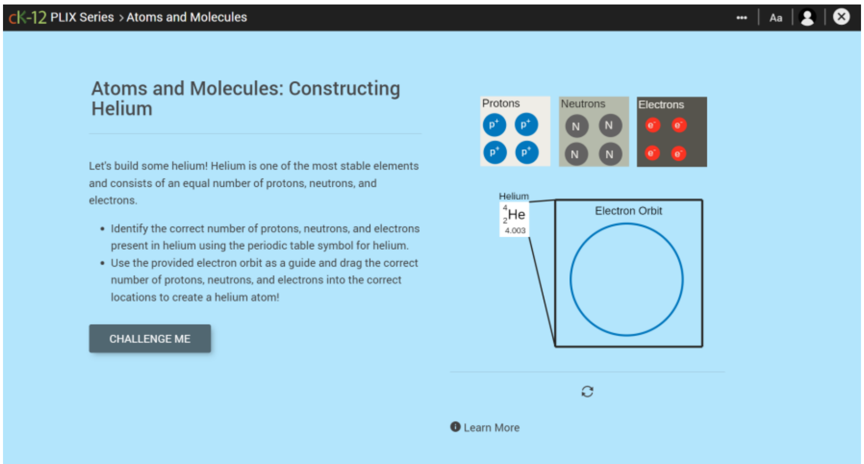

Figure 4. CK. 12 Atom and Molecules

FINDING AND DISCUSSION

The impact of the virtual lab through nuclear physics lectures on the level of reflective thinking ability in terms of the average analysis of the results of the reflective level questionnaire is shown in **Figure 5**.

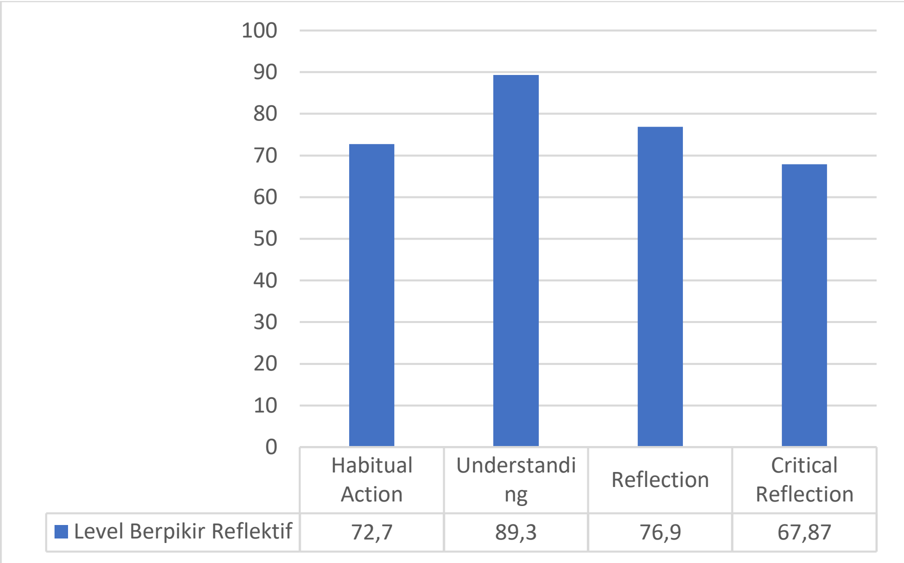

Figure 5. Percentage level of reflective thinking

Based on these data, it was found that the Habitual Action Level was 72.7%, meaning that students were used to doing activities that were often studied before (accustomed) and carried out automatically through conscious thought. This habit is like students: 1) believe that if you often practice working on nuclear physics practice questions, then one day if you encounter a similar problem you can easily solve it and do it well, 2) think if you pay attention to the explanation from the lecturer and then study it again independently then students will understand more.

The Understanding level has the highest percentage, namely 89.3%, meaning that students have been able to take advantage of existing knowledge, without trying to assess that knowledge and learn to stay in a pre-existing scheme or perspective. Just as they have: 1) understood that learning nuclear physics makes it easier to solve problems in society, 2) rethinking the benefits of learning nuclear physics, 3) realizing that by understanding the lecturer's explanation well, they can do assignments well.

At the reflection level of 76.9%, it means that students have been able to criticize assumptions about the content or problem-solving process. Based on the results of the responses to the statement that students agree 1) when their friends succeed in finding solutions to problems in nuclear physics, it sparks their interest in trying even simpler approaches, 2) that they always repeat tasks that have been done using the others and it's easier for them, 3) always rethink what I'm trying to do during nuclear physics lectures to see opportunities in an effort to improve the positive things that have been done, 4) often evaluate myself against learning experiences while I'm in college nuclear physics and try to improve my performance in the future and 5) evaluate myself against nuclear physics concepts that I find difficult and I try to find solutions.

The Critical Reflection level has a percentage of 67.87%, meaning that students are able to critically review presuppositions from previous learning both consciously and unconsciously and 32.13% of students are not yet at that level. Seen in the response to the statement "In my opinion in lectures at nuclear physics the most important thing is that I get good grades and graduate, for further content understanding I can learn anytime and anywhere" students who agreed were 73.4% or 11 students. This answer indicates that students have not understood the important things in the nuclear physics course itself because the most important thing is grades, not understanding concepts. According to Theobald et al., (2017) if students critically review the learning that has been carried out by involving experiences, actions in learning by interpreting and assessing the importance of concepts as fundamental understanding, it will increase the level of reflection and critical reflection. Based on the percentage of the four levels, it is categorized that the level of prospective physics teacher students is in the high category. But the highest is at the level of understanding.

The increase in student reflective thinking is also influenced by the lecturer's evaluation of the learning carried out in order to correct deficiencies in the application of learning. Improvements were made at the problem exploration and reflection stage to improve the quality of learning so that the next meeting would be better.

Learning through a virtual laboratory in nuclear physics courses greatly contributes to the development of students' reflective thinking skills. Through the virtual lab, it has significant benefits and impacts in preparing students to have direct experience in dealing with simulated situations or experiments that reflect the real world (Julianti et al., 2023; Muhajarah & Sulthon, 2020). After running virtual experiments, students can reflect on their experiences and analyze the results obtained. This helps them practice their reflective thinking skills by considering their actions and understanding during the experiment. Besides that, the virtual lab is also able to improve scientific literacy and student process skills such as in research (Elisa et al., 2021; Saputra et al., 2018).

Students can also identify errors during repeated experiments or simulations. Students can perform error analysis and evaluate it and find alternative solutions. Virtual laboratory presents situations or scenarios that require students to make decisions about the next steps. Through reflective thinking, students can evaluate, consider the advantages and disadvantages of each, and contemplate the consequences of each choice. This helps them develop decision-making abilities. In addition, students can receive direct feedback about the results of their experiments. This feedback can trigger reflection about the process, understanding of concepts, and steps taken. By analyzing the feedback, students can identify what needs to be improved. This is what encourages the development of reflective thinking in responding to feedback to improve learning outcomes.

Through experience and interaction in virtual laboratory learning on nuclear physics students can train and develop their reflective thinking skills. This will help them become more critical, independent learners, and able to optimize their learning outcomes in nuclear physics and other disciplines.

CONCLUSION

Virtual Laboratory in nuclear physics learning is very important to implement to facilitate the lack of adequate equipment in real laboratories and facilitate students to carry out experimental activities with a high level of safety. Mastery of concepts in nuclear physics courses is not enough to be a provision for prospective physics teacher students, but reflective thinking skills must also be developed and trained through learning. Based on the virtual laboratory implementation in nuclear physics courses, it shows that the reflective thinking profile of physics teacher candidates is in the high category in the following order: understanding, reflection, habitual action and critical reflection.

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