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AUTHENTIC-INQUIRY-PROJECT ABOUT NYALE ON SCIENCE TEACHERS CRITICAL AND CREATIVE THINKING SKILLS

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ABSTRACT

The aim of this study was to determine the effect of authentic inquiry project practicum on Nyale in improving critical and creative thinking skills of prospective science teacher students. The method used was experimental research method with one group pretest postest. The research subjects involved science education students of one of the universities in Sumba in the 2023/2024 academic year who contracted animal anatomy and physiology courses. The instrument used in this research was a critical and creative thinking skills test. The results of the Wilcoxon test showed that in experimental classes 1 and 2 there was an effect of practicum on the critical and creative thinking skills of prospective science teacher students as evidenced by the Asymp. Sig. (2-tailed) 0.000 < than 0.05. In addition, the N-gain test results showed an increase in critical thinking skills before and after practicum in experimental classes 1 and 2 with moderate categories. While the N-gain test of creative thinking skills showed an increase in the creative thinking skills of prospective science teachers in the moderate category for experimental class 1 and in the low category for experimental class 2. From the results obtained, it can be concluded that the authentic inquiry project practicum on Nyale is effective in improving the critical and creative thinking skills of prospective science teachers.

Keywords: *authentic-inquiry-project,* creative thinking skills, critical thinking skills, *nyale*

INTRODUCTION

Higher education has a big task in preparing skilled workers who have adequate abilities and skills so that they can adapt to the rapid progress and changes in the world. As a society living in the 21st century, universities must be able to provide students as a society with a learning process that must be able to make them have the quality to compete in the global world concerning sustainable development goals (Burn, 2020; Mian et al., 2020; UNESCO, 2017). The basic skills of the 21st century are critical thinking skills, creative thinking skills, problem-solving skills, communicating, and collaborating (Nurkhin & Pramusinto, 2020; Tang et al., 2020; Levin, 2012; Gunn et al., 2008). These skills are needed considering that life changes in the 21st century as the era of human capital have a wide impact in free competition in every aspect of human life.

As part of a society living in the era of human capital, students need to be equipped with various thinking skills that can make them individuals who have sensitivity and are ready to adapt to progress. Students must be able to apply knowledge and ideas in solving real problems found in their lives (Kwangmuang, et al., 2021; Lin et al., 2020; Akben, 2020; Szabo et al., 2020; Rahayu & Rustiami, 2017). Critical thinking, creative and problem-solving skills are 21st century skills that are an important component of high-level thinking to be able to see and find solutions

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to solve all problems encountered (Sthephenson Sadler, 2016).These skills are the focus of attention in education because of the importance of these skills in dealing with the rapid advancement of science and technology. These skills have also become important and cultivated in science education, especially in the scientific process. (Hetherington et al., 2020; Thornhill-Milles et al., 2023; Fitriani et al., 2020) so, learners can have the ability to analyze and evaluate information or problems through observation, experience, and solve complex problems by gathering information, and being able to communicate findings effectively (Haryani et al., 2021; Calavia et al., 2021; Gunawan et al., 2020; Hutabarat, & Phongsavath, 2023).

Teaching and equipping skills requires a learning process that is able to involve learners in actively receiving, creating and or revising their learning results into an experience that is useful for their lives. Learning will be meaningful if learners are able to link the information they have obtained in learning with their prior knowledge. Concepts obtained in learning will become meaningful if they can then be logically connected to other concepts that exist in their lives (Cai et al., 2021; Asad et al., 2021; Altmeyer et al., 2020).

Science learning should be able to make students see problems in real life and come up with ideas or creative solutions to overcome the problem. However, this requires a good and structured planning and process. Students must be encouraged to participate in developing higher-level thinking, improving cognitive and metacognitive skills in understanding what they are learning so that they can express their ideas on the problems they face (Collins, 2014; Huang, & Wu, 2022; Jansen, 2022; Lu et al., 2021). Without such learning conditions, students will experience obstacles in improving high-level thinking skills.

Based on the results of the preliminary study, the curriculum used by the Science Education study program at one of the private universities in Sumba refers to KKNI level 6. This curriculum requires Bachelor graduates to be able to apply, study, design, and utilize science and technology in solving procedural problems. This shows that the curriculum of the Science Education study program is oriented towards learning that emphasizes high-level skills such as critical thinking skills and creative thinking skills. In reality, based on the results of observations, it was found that the implementation of the learning process in the science education study program had not reached this stage.

The results of observations on the implementation of lectures and practicums show that the learning process still emphasizes mastery of concepts. This is reinforced by the results of observations on the implementation of practicum that takes place is still verification. The practicum is carried out with a cook book guidebook, meaning that the guidebook has explained in detail the objectives to the work procedures. This led to the low critical and creative thinking skills of the students. The low of critical and creative thinking skills of students can be seen from the initial test results of students' critical and creative thinking skills.The initial test results on students' critical and creative thinking skills showed that students' critical thinking skills in each indicator of critical thinking skills were still in the poor category. Students' abilities in the elementary clarification indicator were 32.5, in the basic support indicator 25, the advance clarification indicator 35.25, the inference indicator 28.75 and the strategy and tactics indicator 25. While in the creative thinking skills test on each indicator also shows that students are still in the poor category. In the Fluency indicator, students scored 23.3, flexibility indicator 26.8, redefinition indicator 25, elaboration indicator 25 and originality indicator 33.3.

Based on this problem, it is necessary to develop a process of learning and practicum that trains critical and creative thinking skills. The learning activities that are designed must be able to answer the challenges of the need for continuous learning for students as learners. The learning must make students able to contextualize their learning, so that the learning becomes more meaningful (Onowugbeda et al., 2024; Budiman & Setyawan, 2021; Madrazo & Dio, 2020).

Authentic learning creates an understanding of the concepts learned by connecting to new practices that integrate previously acquired experiences (Nunes & Giambastiani, 2021; Colomer et al., 2020; Herrington et al., 2015; Roach et al., 2018). Meanwhile, inquiry project-based learning emphasizes active learning from students to seek and find a solution to the problems encountered (Lopera et al., 2022; Karan &Brown, 2022; Chua Islam, 2021; Almulla, 2020). This activity will then foster systematic, logical, critical thinking skills as well as mental development. The authentic inquiry project-based practicum emphasizes problem solving related to real-life problems. Through authentic inquiry project, students are motivated in learning, teamwork, collaboration in achieving high level academic according to the needs of 21st century life (Kennedy Sundberg, 2020; Pena, 2021; Brandt, 2020).

In authentic inquiry project learning, one

of the real-life problems that can be developed in the learning process is related to Nyale. Nyale is a seaworm included in the Phylum Annelida (Polychaeta) that spawns in the waters of Sumba in a specific month. Nyale in Sumba tradition is important because it is related to the pasola tradition which is one type of ancestral culture that is now a tourist attraction. In addition, the people of Sumba also recognize Nyale sand which has been used by the local community as fishing tackle. Globally, seaworms are Polychaeta that have a relatively short life cycle and strong reproduction that has economic value as the main prey for benthic fish and as bait for fishing (Kerans et al., 2024; Nascimento & Amaral, 2023; Tiralongo et al., 2023; Simon et al., 2021; Pombo et al., 2020); food supplements in aquaculture, food components as shrimp reproductive stimulants and have high levels of polyunsaturated fatty acids. (Eroldoğan et al., 2023; Willer & Alddridge, 2020).

Nyale is a Polychaeta animal that can be studied in biological science, especially in studying its anatomy and physiology. Through the observation of Nyale's body structure, students can learn the structure and function of its body parts and the physiological process. In addition, students are also invited to find solutions so that the taking of nyale in the habitat does not continue to occur. Students can conduct Nyale cultivation experiments to observe the factors that affect its survival. This characteristic needs attention considering that human activities that often take it in the habitat can affect the survival rate of the Nyale worm itself.

This problem is then developed into one of the learning objects in related courses by conducting an authentic inquiry project-based practicum. The purpose of this study is to improve the critical and creative thinking skills of prospective teachers through authentic inquiry project-based practicum on Nyale (Polychaeta). This research also supports the problem solving of current issues in sustainable development goals (SDGs) such as SDGs agenda 4 on quality education and agenda 14 on life under water. Sustainable education that invites students to see and be able to find solutions to problems in real life. Another sustainable development goal (SDGs) is to protect the underwater life of Nyale (Sumba Polychaeta).

Table 1. Implementation of authentic inquiry project practicum

Learning Stages	Student Activities
Formulate Research Questions	Students read the readings provided by the lecturer and discuss actively to formulate research questions according to the topics discussed.
Planning the Investigation	Students in the group actively plan the investigation by filling in the planning on the student worksheet.
	The worksheet contains the planning of field observations and sampling for identification and cultivation purposes; planning of sand *Nyale* cultivation; dentification of sand *Nyale*.
	Students manage their tasks fairly.
	Students discuss the planning results with the lecturer and classmates to get input and suggestions for improvement (if necessary).
	Students approve the schedule for practicum implementation
	Students prepare tools and materials according to group needs
Investigate	Students conduct investigations or field observations observing *Nyale* habitat and work on tasks according to the agreed division of tasks
	Students conduct *Nyale* cultivation and work on tasks according to the agreed distribution of tasks.
	Students identify *Nyale* and carry out tasks according to the distribution of tasks that have been agreed.
Data Collection	Students collect data by completing all required data related to growth and survival in *Nyale* cultivation activities.
	Students documenting the results of identification
Data Analyzing	Students analyze growth and survival according to the treatment.
	Students analyze (identify) the classification of *Nyale* using appropriate references.
Communicating the Results	Students prepare an overall final report

METHODS

The research method used was experimental research with one group pretest postest (Krishnan, 2024; Sieldlecki, 2020). This research was conducted at one of the private universities on Sumba Island in the Science Education Study Program in the Animal Anatomy and Physiology course. The subjects of this study were science education students who contracted the Animal Anatomy and Physiology course. The implementation of authentic inquiry project practicum was carried out in class A as many as 25 people and B as many as 23 students. Sampling was done using purposive sampling technique. The research design is presented in Figure 1.

The critical thinking skills instrument follows the critical thinking skills indicators of Elementary Clarification, Basic Support, Inference, Advanced Clarification, and Strategy and Tactics. While the creative thinking skills developed include fluency, flexibility, redefinition, elaboration and originality. The implementation of the authentic inquiry project practicum follows the syntax shown in table 1. All data in this study were collected through various instruments used. Qualitative data were analyzed descriptively while quantitative data were analyzed using statistics with the SPSS 23 program. To see whether the authentic inquiry project practicum about Nyale has an effect on improving critical and creative thinking skills, a non-parametric test was conducted because the results showed that the data were not normally distributed. Furthermore, to see how much the increase in critical and creative thinking skills, the N-gain test was conducted. N-gain is a term that indicates the value of "Normalized Gain", which is used to measure the relative increase in scores between test results after intervention (sf) and test results before intervention (si). The gain value is obtained by comparing the results of the posttest value and the pretest value.

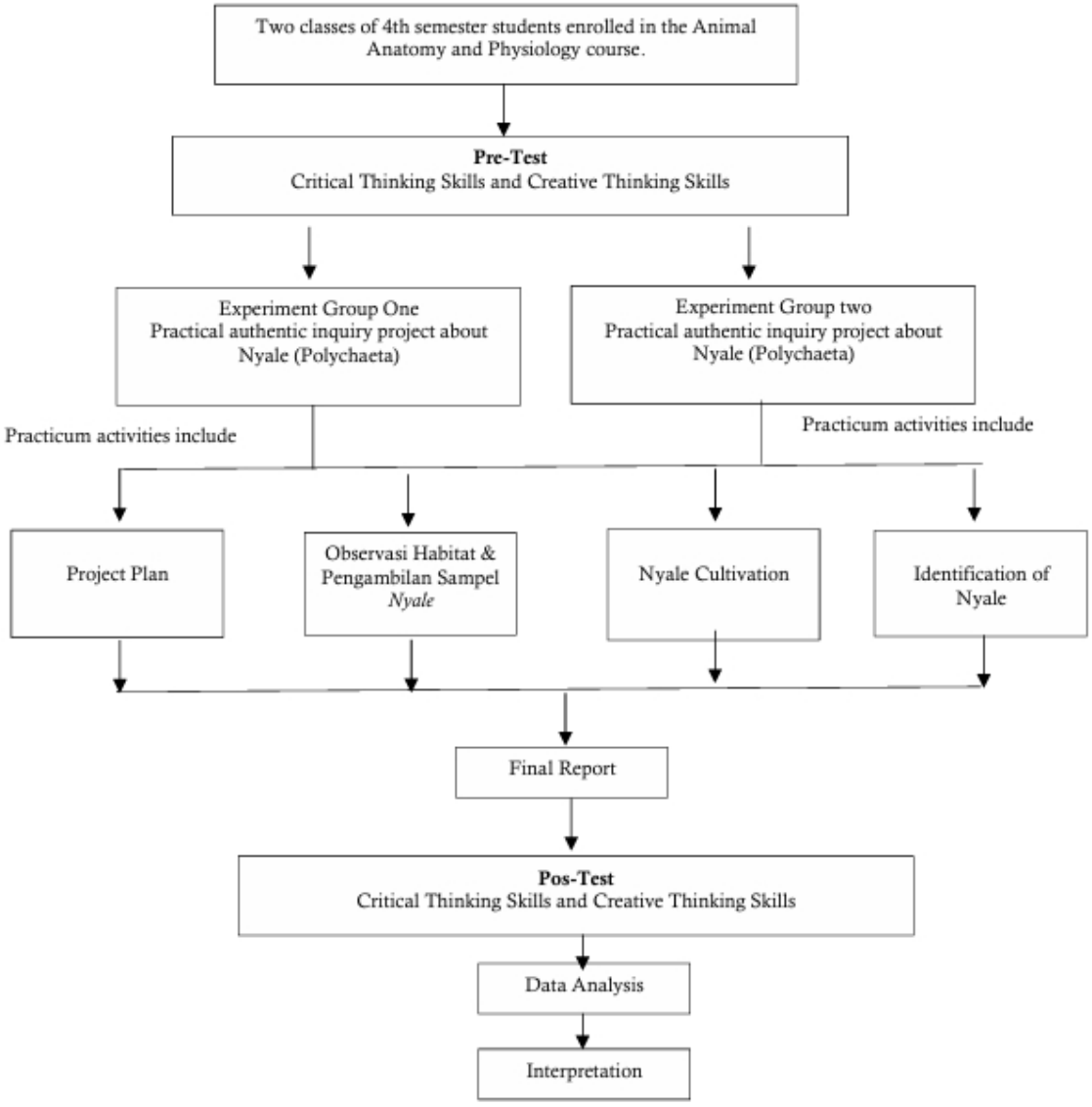

Figure 1. Research design (experimental research with one group pretest postest)

RESULTS AND DISCUSSION

Nyale is a type of marine worm of the Polychaeta class that has an important meaning for the people of Sumba. Nyale, which emerges once a year to the surface of sea water in Sumba, is a moment that is awaited by the community. They will flock to pick up Nyale which will then be used as a side dish for consumption. The people of Sumba also recognize the existence of Nyale sand which is used by the community as fishing bait. The continuous collection of sea worms in their habitat is feared to disrupt the survival of these animals. This research invites students to think critically and creatively to see and address the problems around them.

Research in Animal Anatomy and Physiology Learning, students are invited to carry out a project to identify the structure and function of the Nyale body and try alternative Nyale cultivation to overcome the problem of continuous Nyale Sand collection in its habitat. The Nyale used in the animal anatomy and physiology project is sand Nyale taken from the sand habitat.

This research was conducted on two experimental groups by conducting an authentic inquiry project practicum on Nyale. The practicum was conducted in four times meetings. The first meeting students were invited to identify the Nyale problem by reading two readings prepared by the lecturer. At this meeting also after students determine the next research problem students are invited to plan the project with active discussion in the group. In planning students are invited to formulate project problems and make work plans. The second meeting, students conduct field practicum to observe the habitat of Nyale pasir (Polychaeta) and take Nyale samples that will be used in the cultivation and identification process, the third meeting, students identify Nyale using a microscope. Meanwhile, the cultivation stage is carried out from sampling in the field until the 35th day. All practicum results are then reported by students through the final group report. In the practicum process, students are trained in critical and creative thinking skills. The Student Worksheet designed and used as a guide has been developed to train students' critical and creative thinking skills. In the practicum, students work in groups because in learning there are abilities that cannot be obtained if working alone and in groups will bring up a variety of ideas and ideas that vary (Sanchez-Muñoz et al.,2022; Yuan & Stapleton, 2020; Li et al., 2020; Kowalski et al., 2016).

The results of the pretest and postest of students' critical and creative thinking skills before and after implementing the authentic inquiry project practicum can be seen from the average score data displayed in Figure 3. The results of the pretest and postest of critical and creative thinking skills were then tested to see if the values were normally distributed. The results of the Shapiro-Wilk normality test show that the data on the value of students' critical and creative thinking skills are not normally distributed so that further non-parametric tests need to be carried out using the Wilcoxon test.

Figure 2. a. Pungut Nyale Tradition in Sumba; b. Nyale

The results of the Wilcoxon test of pretest and posttest values of critical thinking skills in table 2 can be interpreted as follows 1) Negative Ranks or the difference (negative) between the test results of students' critical thinking skills is 3 at the N value, which means that there are 3 students who have decreased scores from the pretest results to the posttest scores. 2) Positive Ranks or the difference (positive) shows that the results of the student critical and creative thinking skills test with a value of N is 44, which means that of the 48 students who took the tets there were 44 students who experienced an increase in critical thinking skills from the pretest value to the posttest value. 3) Ties are the similarity of pretest and posttest scores. The value of ties is 1 which means there is 1 value that is the same between the pretest value and the posttest value. 4.) The value of Asymp. Sig (2-tailed) value is 0.000, indicating that the practicum of authentic inquiry project about Nyale has an effect on improving students' critical thinking skills.

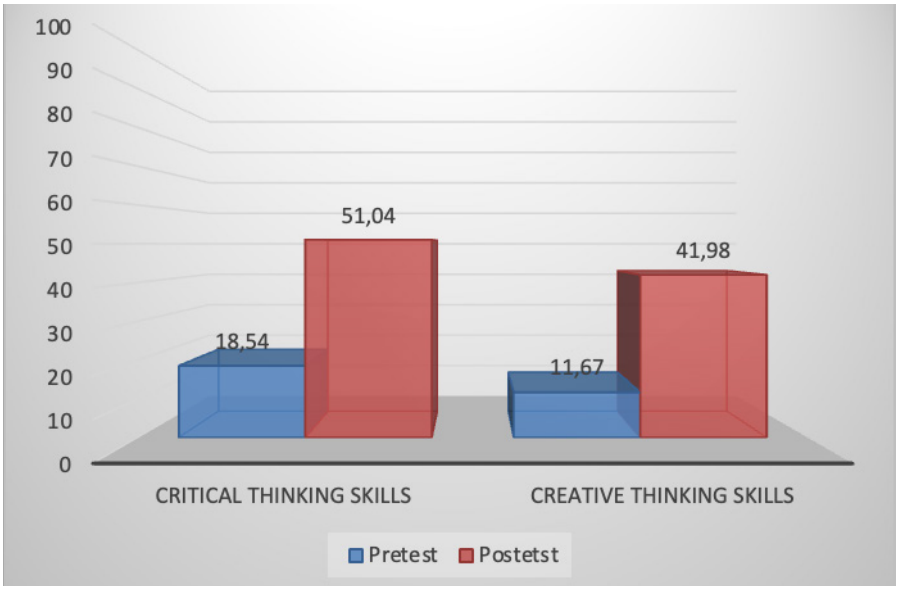

Figure 3. Diagram of Pretest and Posttest Results of students' critical and creative thinking skills.

Table 2. Wilcoxon test Critical thinking skills and creative thinking skills

Indicators	Value	N	Mean Rank	Sum of Rank
Critical Thinking Skills	Negative Ranks	3[a]	3.17	9.50
	Positive Ranks	44[b]	25.42	1118.50
	Ties	1[c]		
	Total	48		
	Asymp. Sig. (2-tailed)	0.000		
Creative Thinking Skills	Negative Ranks	2[a]	6.75	13.50
	Positive Ranks	46[b]	25.27	1162.50
	Ties	0[c]		
	Total	48		
	Asymp. Sig. (2-tailed)	0.000		

The practicum process of authentic inquiry project about Nyale in the process trains students to think critically by identifying real problems that exist in students' daily lives. Students identify problems in groups and then discuss the problem-solving process. The problems faced by students are problems that exist around students, making students more interested and challenged. In addition, this is a new activity because the Nyale that has been known so far has never been cultivated. The activeness of each member in the discussion and in every stage of the project both in the field and in the laboratory provides new experiences and skills for students.

This activity then has an impact on improving students' critical thinking skills. These results are in line with previous research which states that critical thinking skills acquired by students through problem solving exercises will make them build an understanding of science by reasoning through problems, looking for scientific facts and looking for scientific evidence (Young et al., 2023; Sutiani et al., 2021). Critical thinking and science education go hand in hand with four

foundations for building learning experiences: a) science, technology, and society; b) knowledge; c) skills; and, d) attitudes. Researchers view attitudes as the foundation for the other three foundational areas, without it, critical thinking is nothing more than a theoretical exercise (Kwangmuang et al., 2021; Demircioglu et al., 2023). Afterwards, the N-gain test was conducted to see how much the students' critical thinking skills improved after doing the practicum. The increase in critical thinking skills can be seen in Table 5. Table 5 shows that the increase in thinking skills of students in experimental groups one and two after taking practicum is in the medium category.

Table 5. Improvement of Students' Critical Thinking Skills

Class	Pretest Value	Posttets Value	N-gain	Category
Experiment 1	14.42	53.46	0.467	Medium
Experiment 2	23.40	48.18	0.327	Medium

Creative thinking skills as one of the skills needed in the 21st century is the skill of students in creating or making new ideas that make them feel able to achieve their life goals (Thornhill et al., 2023; Larraz-Rábanos, 2021; Rosen Simmering, 2020). The results of the Wilcoxon test of pretest and posttest values of creative thinking skills in table 4 can be interpreted as follows 1) Negative Ranks or the difference (negative) between the test results of students' critical thinking skills is 2 at the N value, which means that there are 2 students who have decreased scores from pretest results to posttest scores. 2) Positive Ranks or the difference (positive) shows that the results of the student creative thinking skills test with a value of N is 46, which means that there are 46 students who have increased critical thinking skills from the pretest value to the posttest value. 3) Ties are the similarity of pretest and posttest scores. The value of ties is 0 which means there are no similar values between the pretest and posttest values. 4.) Asymp. Sig (2-tailed) value is 0.000, indicating that the practicum of authentic inquiry project about Nyale has an impact on improving students' creative thinking skills.

To see how much the improvement of students' creative thinking skills after doing the practicum, the N-gain test was conducted. The test results can be seen in table 6. From the table it can be seen that the increase in creative thinking skills of experimental group 1 students after participating in the practicum is in the medium category while in experimental group 2, it is still in the low category. Students in experimental group 2 have lower scores when compared to experimental group 1 due to differences in the level of activity in the discussion. all treatments and processes undergone by these two classes remain the same but because of the differences in the level of activity in each process, it also has an impact on the skills obtained.

Table 6. Improvement Students' Creative Thinking Skill

Class	Pretest Value	Posttets Value	N-gain	Category
Experiment 1	9.038	47.5	0.428	Medium
Experiment 2	14.77	35.45	0.241	Low

The results above show that students' critical thinking and creative skills improved after participating in the authentic inquiry project practicum on Nyale. The application of learning that emphasizes critical thinking skills, creativity and problem solving is one of the important factors in 21st Century learning (Thornhill-Miller et al., 2023; Southworth, 2022; Li et al., 2020; Kapici et al., 2020).

Critical thinking skills invite students to achieve goals in an efficient way that involves various cognitive, attitudinal, motivational and metacognitive functions. Critical thinking becomes useful for students to be able to plan, manage, monitor and assess not only limited to what is learned in the classroom but wider than that, namely in everyday life as a person and social society. (Thornhill-Miller et al., 2023; Al-Ghadouni, 2021; Chen, 2021; Wechsler et al., 2018; Nurkhin & Pramusinto, 2020). Creative thinking skills invite students to connect complex material with new and valuable ideas (Winarso & Haqq, 2020; Chen et al., 2022). Creativity relates to the creative person, problem solving, cultural context and new products (Larraz-Rábanos, 2021; Corazza & Glăveanu, 2020). In this research, students are invited to become creative individuals by raising real-life problems, namely Nyale as one of the uniqueness of Sumba that needs to be conserved.

In the learning process, critical and creative thinking skills can be improved with a learning development that is arranged in such a way that the entire series of learning processes can be student-centered (Tholibon et al., 2022; Sanchez-Muñoz et al, 2020; Aytac & Kulla, 2020; Villar-

roel et al., 2020). In addition to being student-centered, the current learning demands are also how to design learning that is able to contextualize the learning so that it becomes meaningful learning for students (Hagenkotter et al., 2024; Nachtigall & Rummel, 2022; Sanchez-Muñoz et al, 2020). In order to answer these problems, there are various learning models that are able to contextualize learning to be more meaningful, namely authentic inquiry learning based on projects (Kerans et al., 2024; Hernández-Torrano & Ibrayeva, 2020). The authentic inquiry project learning provided to students connects learning materials with real-world problems so that students can work like scientists and interact with the material being taught. This learning provides students with effective, motivating and successful learning (Zachrich et al., 2024; Mierwald et al., 2022; Fougt et al., 2019). Authentic learning allows students to exercise their academic abilities and connect them with their experiences directly, making learning more active and student-centered (Macdiarmid et al., 2024; Brookes et al., 2020).

In this study, experiments were conducted using only sand Nyale worms but not Nyale that have habitats on coral reefs, which are thought to be Nyale that appear once a year and reproduce en masse. In the experiment, the research did not look at the effect of feed in the cultivation process and the identification process was still very simple due to equipment limitations. For future researchers who want to raise experimental research using Nyale in the practicum process, they can conduct cultivation by paying attention to the feed factor and also the type of Nyale used in the cultivation process. In addition, authentic inquiry project research needs attention, especially in its implementation in classes that have never done inquiry or project-based practicum before. Lecturers need to pay better attention so that student achievement can be optimal.

CONCLUSION

The authentic inquiry project practicum on Nyale improves the critical and creative thinking skills of prospective science teacher students. This is evidenced by the results of the Wilcoxon test both on the test results of students' critical and creative thinking skills there is an influence and an increase in the moderate category. The practicum process designed by raising problems in real life students train students to think critically and creatively. In addition, the series of processes designed in such a way with student worksheets that train these thinking skills make students more active. Practical activities in small groups make all students actively involved and complement each other and enrich new ideas or ideas. The authentic inquiry project practicum activity on Nyale also has an important impact in supporting the SDGs program. Higher education in its sustainable learning has a minimal impact on the environment. The understanding of Nyale also invites students to be directly involved in maintaining the sustainability of Nyale's life (Polychaeta from Sumba).

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