The development of teaching materials of the potential coral reefs in Tiga Island Natuna on the concept of ecosystem

R Halim\textsuperscript{1*}, B Supriatno\textsuperscript{2}, and Amprasto\textsuperscript{2}

\textsuperscript{1}Sekolah Pascasarjana, Universitas Pendidikan Indonesia, Jl. Dr. Setia Budhi No. 229, Bandung 40154, Indonesia
\textsuperscript{2}Departemen Pendidikan Biologi, Universitas Pendidikan Indonesia, Jl. Dr. Setia Budhi No. 229, Bandung 40154, Indonesia

*rosdianahaim@upi.edu

Abstract. The purpose of this study is to develop teaching materials about coral reefs Tiga Natuna Island in Biology learning on ecosystem material in high schools. The research method used was descriptive analysis, and the research model used was ADDIE (analysis, design, development, implementation, and evaluation). However, the completion of this teaching material was still in the testing phase. The weak experimental method with the one-group pretest-posttest design was conducted in this testing phase. Sixteen students were selected by purposive sampling in grade X Public High School. Data was collected through instruments written tests. The test was arranged based on the indicator of environmental literacy on the knowledge aspect. Then, data was tested by N-gain. Based on the results of the testing of this teaching material obtained n-gain of 61.78 (medium category). The average pretest-posttest score of students was 50.16 and 85.61.

1. Introduction
Natuna island is located between 1 ° 16 ' - 7 ° 19' North Latitude and 105 ° 00 ' - 110 ° 00' East Longitude. The northern part of Natuna Island is bordered by the South China Sea, the south by the Bintan Regency, the West by the Malaysian Peninsula, and the East by the South China Sea. One location that has the potential of coral reefs in Natuna Island is Sabang Mawang Village. It is one of the villages in the Tiga Island District. The village typology has an area of 120 km\textsuperscript{2} including islands and coastal villages. Education is one of the important efforts in shaping human resources that can compete with various competency demands in the 21st century. The developing era influences many aspects of life including the demand for the quality of education [1]. Education continues to experience development and advancement in the level of technology and Human Resources (HR). Therefore, education is expected to be able to connect individuals with their environment [2].

The above objective can be achieved when teachers in the school prepare appropriate teaching materials. The teaching materials must be following the demands of the current curriculum implemented by the Government (2013 curriculum). This curriculum emphasizes learning that is more applicable in everyday life. Biology is one of the subjects which is an important part of education. The context of biology is inseparable from real objects such as living things and their environment. Therefore, learning and teaching materials must be applied more contextually. Contextual teaching
materials can be achieved by utilizing the local potential around the students’ environment. The local potential internalized through biology learning influences many educators to develop biology teaching materials as a tool to present learning materials.

The potential of coral reef ecosystems in Tiga Island Natuna has not been internalized and implemented by teachers by emphasizing the cognitive abilities of students so that it results in learning processes that are not contextual. Poor environmental conditions can be caused by a lack of social knowledge about ecology [3]. If humans cannot act wisely in protecting coral reef ecosystems, it is estimated that by 2025 the sea will experience an ecological imbalance [4]. One effort that can be done to overcome the above problems is to foster environmental literacy to students. This suggests students to protect the environment through biology learning. Biology teaching materials by utilizing the local potential of coral reefs Tiga Island Natuna are considered to produce more contextual learning resources. Integrating learning materials according to the surrounding environmental issues can help students solve environmental problems more easily [5]. Based on the field review conducted, there is one of the public high schools with a significant number of students on Tiga Island Natuna. The students at the school are very close to the sea and coral reefs that are around them. This condition supports that learning resources should be used by the teachers by optimizing the development of the local potential-based teaching materials of coral reefs in Tiga Island Natuna

2. Methods
The research method used was descriptive analysis, and the research model used was ADDIE (analysis, design, development, implementation, and evaluation). The stage of analysis was started with need assessments, namely analysis of basic competencies, learning materials, lesson plans, and an exploration of the environmental conditions in coral reef ecosystems and a potential inventory of the existing ecosystems. The results of both exploration and inventory were described in a book used as the teaching material. Then, the design and development of teaching materials was carried out, the development of teaching materials was based on the results of revisions and trials on a group of students. This teaching material was implemented on the ecosystem concept in class X high school. The stages of analysis, design, development, and implementation undergo an evaluation and revision process of education and ecology experts. However, the completion of this teaching material was still in the testing phase. The weak experimental method with the one-group pretest-posttest design was conducted in this testing phase. The weak experimental method with the one-group pretest-posttest design was used for the test’ stage (trials). Sixteen students were selected by purposive sampling in grade X Public High School. Data was collected through instruments written tests based on the indicator of environmental literacy on the knowledge aspect. Then, data was tested by N-gain.

3. Result and Discussion

3.1. The condition of coral reefs in Natuna island.
Figures 1 and 2 shows the condition of coral reefs in Natuna Island. Natuna Island is one of the islands known to the public for its beautiful coral reefs. When viewed from an economic perspective, this coral reef ecosystem is also the main livelihood for the surrounding coastal communities [7]. Coral reef ecosystems are resources that have ecological and socio-economic functions. The existence of coral reef ecosystems is very important for the society of coastal and small islands because their livelihoods depend on shallow marine fisheries [8]. The potential of coral reefs on the Natuna Island provides benefits for the lives of surrounding communities including the education sector.

The coral reef ecosystems in Tiga Island Natuna consists of biotic and abiotic components. Abiotic conditions affect the life of living things around them. The previous research revealed [10] that salinity in Natuna ranges from 32-36 ppt with the water temperature that is not so varied, which is between 27-300C. The temperature determines the density of water in influencing phytoplankton conditions. The
pH value ranges from 7.9 to 8.2. In general, the brightness value of the water there is still very good which ranges from 0.8-22.1 m [9]. Water flow conditions in the Natuna island range from 0.17 to 0.20 m / s [10].

![Figure 1. The condition of coral reefs on the uninhabited islands](image1)

![Figure 2. The condition of coral reefs on the inhabited islands](image2)

Figures 1 and 2 show that biotic components found in coral reef ecosystems included; various types of coral, phytoplankton, zooxanthellae, seaweed, red algae, zooplankton, Porifera, sea urchin, crustacea, mollusks, echinoderms, reef fish and other herbivorous fish, bacteria, and fungi. The abundance of herbivorous fish shows a greater role in coral reef ecosystems [11]. Based on their functions, each biotic component acts as a producer, consumer, and decomposer. The existence of live coral, coral cover, and the form of coral growth has a positive relationship with the abundance of reef fish [12]. This exploration showed that there were interactions between coral reef organisms such as vertebrate animals (fish) that live on coral reefs as shelter, foraging, and so on. The presence of herbivorous fish affected the growth of algae. An abundance of herbivorous fish decreased algae cover in the coral reef ecosystems [12].

3.2. The types of corals.
Figures 3, 4 dan 5 show that overall, the coral reefs found were in good condition. However, there were some that have been damaged. The types of corals that were identified as being in good condition were Acropora humilis, Acropora aspera and Acropora millepora. While some corals damaged were Acropora rugosa, Acropora samoensis, and Acropora intermedia.

![Figure 3. Acropora aspera](image3)

![Figure 4. Acopora humilis](image4)

![Figure 5. Acropora millepora](image5)
3.3. The physical damage that occurred in corals.
Figure 6 shows that the coral reef has been damaged. In addition to observing coral reef ecosystem components, this study also described the damage to coral reefs. Coral damage was caused by bleaching due to boat anchors, potassium, or explosives. Coral bleaching was seen on Acropora intermedia corals. From the results of observation, it was estimated that some of the colonies also experienced bleaching. Coral bleaching was seen in changes in coral that were very bright on Acropora Intermedia.

Figure 6. Damage on corals figure

Figure 7. Bleaching on Acropora intermedia

Figure 7 shows that the physical damage that occurred in corals. Based on observations in the current study, coral bleaching that occurred was most likely caused by sedimentation. Some types of coral had experienced sediment in the form of mud that settled on the surface of the coral. Sedimentary particles had coarse and fine sizes depending on place or location, geological base, and depth [13]. This damage was caused by the use of anchors so that the coral broke and died. Therefore, an appropriate coral reef management strategy is needed.

3.4. Table 1. Some types of coral reef.
Table 1 shows some types of coral reefs found in Natuna Island. Various types of corals were found in the coral reef ecosystems. The Acropora species was the most common type of coral reef found in Natuna Island.

| Types of coral reefs       | Types of coral reefs         |
|---------------------------|------------------------------|
| Porites rugosa            | Acropora rugosa              |
| Porites mayeri            | Acropora sarmentosa          |
| Leptoria phygia           | Acropora robusta             |
| Acropora humilis          | Montipora stella            |
| Acropora millepora        | Pavona frondifera           |
| Acropora samoensis        | Pavona venosa               |
| Acropora intermedia       | Tylocoeniella gaentheri  |
| Acropora gemmifera        | Montastrea magnistellata    |
| Acropora nobilis          | Goniastrea pectinata       |
| Acropora aspera           | Pseudosiderastrea tayami   |
| Acropora prosiata         | Montastrea selabrosa         |

3.5. Analysis of the Local Potential of Coral Reefs in Biology Learning
The curriculum used at public high schools in Tiga Island Natuna is the 2013 curriculum. However, the teachers still use general learning resources. The teachers had not linked the lesson by exploiting the potential of the natural surroundings. Meanwhile, learning resources should be packaged properly to facilitate students in obtaining information, knowledge, experience, and learning process skills [14]. The role of teaching materials in education according to the Ministry of National Education in 2010 is to establish the principles of the benefits of the development of teaching materials; a) the principle of the relevance of the material that must be following the demands of Core Competency (KI) and Basic
Competency (KD), b) the principle of consistency or constancy, and c) the principle of adequacy, namely the adequacy of teaching material in achieving competency as taught by the teachers [15]. The criteria for good learning resources are those that are following clarity of potential, clarity of objectives, appropriateness of learning objectives, and clarity of teaching material guidelines in helping to improve students' environmental literacy.

3.5.1. Clarity of the potential
The local potential of Tiga Island Natuna is closely related to the daily lives of students. The Local potential was revealed through observation and inventory since nowadays students need contextual learning. Contextual learning can be applied by utilizing the existing local potential to train students to uncover many facts and phenomena so that they are more familiar with the area and enrich their environmental literacy.

3.5.2. Clarity of target
Based on conformity with the learning objectives, teaching materials were prepared by utilizing the local potential applied to class X students in one of the public Senior High Schools in Tiga Island Natuna. Students became the target of the developed teaching material. The teaching material developed was tailored to the needs and characteristics of students since they have heterogeneous abilities.

3.5.3. Conformity with learning objectives
Table 2 shows the basic competencies in the ecosystem topic. Based on studies on the present research, the potential of coral reefs on Tiga Island Natuna had an equivalency with the 2013 curriculum. The potential of coral reefs was suitable with the Core Competency (KI) and Basic Competency (KD). The conformity meant can be seen in Table 2 namely KD 3.10 and KD 4.10 in class X on the topic of the ecosystem, KD 3.10. Analyzing ecosystem components and interactions between these components. And, KD 4.10. Presenting work that shows interactions between ecosystem components

3.5.4. Clarity of guidelines in improving student environmental literacy
The teaching material developed requires proper consideration in achieving learning objectives. Considerations taken into account were related to the techniques of implementing learning, editing process of teaching materials that must be precise, the practicality of teaching materials, presentation, and so on. In addition to adjusting to the curriculum, this was also adjusted to the specific objectives of developing teaching material that is to increase the environmental literacy of students. The teaching material was packaged in the form of discussions and exercises in increasing the environmental literacy of students. Appraisal instruments were used appropriately so that the purpose of using teaching materials through the potential of coral reefs was clearly illustrated.

Table 2 shows the result of the testing phase on the knowledge aspect. Environmental literacy is knowledge about how the natural environment functions and how humans play a role in protecting and protecting their environment [16]. Knowledge is one aspect of environmental literacy in students [17]. The following are the results of the testing phase on environmental literacy in aspects of knowledge:

| Components | Pretest | Postest |
|------------|---------|---------|
| N          | 16      | 16      |
| Average    | 50,16   | 85,61   |
| N-gain     | 61,78%  |         |
| Category   | medium  |         |
4. Conclusion
This research is preliminary and far from perfect and requires a lot of input from reviewers and the audience. This research can be input for teachers who want to develop coral reef teaching materials and develop ecosystem learning to make it more interesting and enjoyable. This research can also be a picture of teachers who want to implement teaching materials about coral reefs in ecosystem material. The teacher can also try to involve other environmental literacy skills in the ecosystem material.

5. References
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