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Building 21st century skills of multiethnic students: Studying genetic diversity in research-based exploration and the local potential of the north Maluku islands

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Abstract

Biology learning in schools should be related to the environment in which students live and learn based on real or contextual problems in everyday life. Learning like this has the potential to provide meaningful experiences to students. The local potential of the region needs to be explored so that it can be utilized as teaching materials and media and learning resources. This study aims to test teaching materials for genetic diversity based on research exploring the local potential of the North Maluku archipelago region for XII grade students of MAN 1 Ternate city. The research was conducted in two stages, namely the survey stage, namely conducting local potential exploration research in the form of *Drosophila melanogaster* as a need assessment and the learning trial stage based on local potential exploration research. The results of data analysis show that; 1) local potential in the form of morphological characters of *Drosophila melanogaster* in Ternate and Tidore islands varies from the shape of the eyes, abdomen shape, abdomen color and wing shape. 2) the morphological character of *Drosophila melanogaster* has a small similarity coefficient index value, 3) research-based learning exploration of the local potential of the North Maluku islands can improve the 21st century skills of grade XII MAN 1 students.

Keywords: 21st century skills, Genetic diversity, Local potential, Multiethnic students, Research-based exploration.

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1. Introduction

Rapid technological development and complexity make demands on individuals increasingly high. 21st century skills such as critical thinking, creativity, communication and collaboration are crucial for young people to be able to adapt and contribute to a changing society. Education plays an important role in equipping students with these skills. Indonesia, especially the North Maluku Islands region, with its abundant biodiversity, can be utilized for relevant and meaningful science learning. However, this potential has not been optimally utilized in the learning process. Research-based learning, which places students as young scientists who are active in the process of investigation, can be a solution to overcome this challenge.

Today, biology has been instrumental in addressing complex and global issues in the 21st century. According to the National Academy of SciencesRevolution [1] and Council [2] that advances in biological sciences are instrumental and remarkable to address many of the major challenges faced by the world. Therefore, according to Novick and Catley [3] and KHALI, et al. [4] that developments and achievements in biology should be conveyed in the form of biology learning in the classroom. In fact, an interdisciplinary approach to biology, Technology, and Mathematics is suggested to absorb 21st century skills in the existing biology curriculum [5].

The natural wealth of North Maluku is not only limited to biodiversity, but also includes unique cultural, tribal and ethnic wealth. Culturally, the people of North Maluku have a rich cultural diversity, both local and national [6]. This diversity makes schools in North Maluku a microcosm rich in learning potential. Through research-based learning that focuses on genetic diversity, students from different cultural backgrounds can work together on research by exploring the natural resources around them. For example, students can work together in researching the genetic diversity of endemic animals, economically valuable plants and traditional medicinal plants used by each tribe. This activity not only enriches students' knowledge of the concept of genetics, but also fosters a sense of mutual appreciation and respect for cultural diversity. Collaboration between students from different tribes will encourage an inclusive learning environment and enrich their learning experience.

The biology learning curriculum in Indonesia has integrated 21st century skills, namely science process skills and scientific attitudes as well as social and spiritual attitudes. Students' 21st century skills are emphasized on the ability to apply technology through literacy in the digital era, creative and critical thinking and have excellent interpersonal and interpersonal skills [7]. Furthermore, it is explained by Chen, et al. [8] that currently students are also faced with enormous scientific challenges.

The main purpose of learning biology in junior high school is to equip students with skills and knowledge in science and technology, which enable them to solve problems and make decisions in everyday life based on scientific attitudes and moral values [9-11]. 21st century learners must be prepared to become a global society [12, 13]. Furthermore, according toAsikin, et al. [14]; Hernawati, et al. [15]; Suryadarma [16] and Mumpuni, et al. [17] that these demands certainly urge teachers to conduct biology learning by utilizing local potential and scope because biology must be relevant to students' daily lives and needs. Furthermore, it is explained by Nofiana and Julianto [18] and Abidinsyah, et al. [19] in the research results that the implementation of learning that utilizes local potential has potential to improve the ability of content, context, and science processes of students in line with the demands of 21st century learning. These efforts must also be encouraged on an ongoing basis, because the number is still limited and uneven.

Learning becomes interesting and improves student learning outcomes, if it can utilize the results of the exploration of local natural resources that have potential as learning materials and media, so it is hoped that teachers must be able to use learning media based on the results of exploring the potential of local natural resources and not just using blackboards, posters, and other visual media [20].

Empirical facts show that teachers in the province of North Maluku, including biology teachers in the city of Ternate and Tidore islands, still have very little knowledge in developing learning media, especially the concept of genetic diversity by using study objects utilizing the exploration of local potential in the form of local organisms. North Maluku is one of the provinces that has very high biodiversity. The results of a survey conducted by Pagala [21] in several villages in Ternate City showed that 99% of local organisms in the form of Drosophila were found as local potential of the North Maluku islands, but these organisms have not been properly identified. In addition, the local potential of the North Maluku islands has also not been utilized by biology teachers and prospective biology teachers as learning materials and media in schools or research materials.

Observations of teachers at SD/MI in Ternate City conducted by Haerullah and Hadi [20] show that teachers tend to still use blackboard media, posters, and other visual media, not utilizing the potential of local natural resources as learning resources or teaching materials. As a result, students are less enthusiastic in learning the science concepts taught by the teacher. Furthermore, the results of a survey by Haerullah and Hadi [20] of several science-biology teachers also show that in general learning activities in schools are inseparable from the use of textbooks as the only source of learning. Furthermore, Haerullah, et al. [22] states that a professional educator has one of the characteristics of being able to create innovation in learning. The challenges and opportunities of being a teacher today, including in the islands, are the ability to adapt and innovate with learning.

Utilizing the potential of local natural resources for learning in schools has been the concern of researchers in various regions in Indonesia. Several studies, such as Haerullah and Hadi [20]; Haerullah, et al. [23]; Haerullah, et al. [24]; Sahil, et al. [25] and Haerullah, et al. [26] have shown the potential of this approach in improving the quality of learning. The results of these studies, which mostly focus on the development of teaching materials and learning media based on local potential, have made an important contribution in enriching the variety of learning models in Indonesia. However, research that specifically examines the implementation of research-based learning that actively involves students in the exploration of local genetic potential in multiethnic schools in North Maluku is still relatively limited.

One example of the abundant potential of natural resources in the province of North Maluku is Drosophila melanogaster. Therefore, it is necessary to explore the diversity of Drosophila melanogaster in the North Maluku islands, considering that so far in the field of biology education and learning there are no teachers who use local Drosophila species as learning resources in junior high schools / MTs and SMA / MA. According to Beckingham, et al. [27] that Drosophila melanogaster is a model organism for studying the complex biology of multicellular organisms. Thus, it is necessary to explore the local potential of the North Maluku islands region in the form of Drosophila melanogaster as a teaching material for genetic diversity to improve the 21st century skills of SMA / MA students.

2. Materials and Methods

This research consists of two stages, namely the survey stage carried out to explore the genetic diversity of *Drosphila melanogaster* based on morphological characters obtained from several fishing spots in the Ternate and Tidore islands. The results of these observations are then referred to as the results of research exploring the local potential of the North Maluku islands. The next stage is the experimental research stage, conducted to test the effect of learning based on local potential exploration research on 21st century skills of XII grade students of MAN 1 Ternate city

2.1. Procedure

2.1.1. Survey Research Phase

The survey stage was carried out by conducting local potential exploration research in the form of *Drosophila melanogaster* genetic diversity in two puff areas namely Ternate Island and Tidore island. Furthermore, the survey results were used for morphological character observations at the Khairun University biology laboratory. Morphological character observations of *Drosophila melanogaster* genetic diversity were carried out on *Drosophila melanogaster* that live naturally in the North Maluku islands.

2.1.2. Experimental Research Phase (Trial of Exploratory Research-based Learning)

The research results of the exploration of the local potential of the archipelago in the form of genetic diversity, then used as teaching materials and tested on 9th grade students of Madarasah Tsanawiyah SC Ternate to determine the effect of learning genetic diversity based on the exploration of the local potential of the North Maluku archipelago on students' 21st century skills.

2.2. Data Analysis

2.2.1. Data Analysis of Character Observations

The data collected from the observation of morphological characters of *Drosophila melanogaster* from several spots, then tabulated into ratio data obtained through measurement with a ratio scale. Furthermore, dendrogram construction analysis was carried out to describe the similarity and relatedness or to produce a phylogenetic tree of *Drosophila melanogaster* from various islands of Ternate and Tidore based on morphological characters using UPGMA (*Unweighted Pairge Group Method with Arimathic Mean*) cluster analysis using the Multivariate Statistical Package (MVSP) 3.22 program proposed by Kovach [28].

2.2.2. Experimental Research Data Analysis

Data from the exploratory research-based learning trial results that have been collected in the form of *pre-test* and *posttest* results of 21st century skills and students' spiritual intelligence are then analyzed using analysis of covariance (Anakova). Previously, a prerequisite test or normality and homogeneity test was conducted. The normality test used the *One-Sample Kolmogorov-Smirnov test*, while the homogeneity test used *Leven's Test of Equality of Error Variances* [29]. Statistical analysis was performed using *SPSS 19 for Windows software*, and was conducted at a significance level of 0.05 ($p < 0.05$).

3. Results and Discussion

3.1. Survey Research Results

3.1.1. Exploration of the Local Potential of the Islands Region in the Form of Morphological Diversity of Drosophila melanogaster Ternate and Tidore as Materials

The results of data analysis on kinship relationships consisting of matrix similarity analysis (Genetic relationship) and dendrogram analysis show that there are differences and similarities in the Morphological Characters of Drosophila melanogaster Ternate and Tidore. The results of this study can be described as follows:

3.1.2. Similarity Matrix of Morphological Characters of Ternate Islands Male Drosophila Melanogaster

Kinship relationships based on the results of matrix similarity analysis (*Genetic relationship*) and dendrogram analysis. The results of the analysis based on the similarity coefficient using the UPGMA method of Ternate Island males as in Table 1 below:

Table 1.
Analysis of Similarity Matrix (Genetic relationship) of Ternate Islands Male *Drosophila melanogaster* from 30 Individuals Based on Morphological Characters analyzed by the UPGMA method.

	Sasa	**Bastiong**	**Gamalama**	**Dufa-dufa**	**Sulamadaha**	**DanauTolire**	**Fora**	**Moya**	**Jati**	**Tobo**
Sasa	0.000									
Bastiong	0.690	0.000								
Gamalama	1.000	0.861	0.000							
Dufa dufa	0.816	0.690	1.000	0.000						
Sulamadaha	0.856	0.737	0.940	0.856	0.000					
D. Tolire	0.701	0.984	1.000	1.000	0.908	0.000				
Fora	0.707	0.556	0.847	0.707	0.753	0.811	0.000			
Moya	1.000	0.936	1.000	0.632	0.577	1.000	0.949	0.000		
Jati	0.890	0.992	0.908	1.000	0.852	0.940	1.000	1.000	0.000	
Tubo	1.000	1.000	1.000	0.753	0.707	0.996	0.856	0.408	1.000	0.000

The results of the analysis in Table 1, show that the Ternate Islands *Drosophila melanogaster* capture spot has the highest similarity matrix (Similarity coefficient) of 0.996%. In the spots of Tolire Lake and Tubo, this implies that there is the most similarity in morphological characters between the two spots. Furthermore, the lowest similarity matrix (Similarity coefficient) was 0.408% in two capture spots, namely Moya and Tubo spots. This means that based on morphological characters, *Drosophila melanogaster* in these two places have the least or very low level of similarity.

3.1.3. Similarity Matrix of Morphological Characters of Ternate Islands Female Drosophila melanogaster

Data analysis of the results of the similarity matrix of morphological characters of male *Drosophila melanogaster* of the Ternate islands in 10 capture spots showed a kinship relationship consisting of matrix similarity analysis (Genetic relationship) and dendrogram analysis. Based on the similarity coefficients using the UPGMA method of Ternate Island females as in Table 2 below:

Table 2.
Analysis of Similarity Matrix (genetic relationship) of Ternate Islands Female Drosophila melanogaster in 30 Individuals Based on Morphological Characters analyzed by the UPGMA method.

	Sasa	**Bastiong**	**Gamalama**	**Dufa-dufa**	**Sulamadaha**	**Danau olire**	**Fora**	**Moya**	**Jati**	**Tubo**
Sasa	0									
Bastiong	0.707	0								
Gamalama	1.000	0.707	0							
Dufa dufa	1.000	0.737	1.000	0						
Sulamadaha	0.500	0.500	0.500	0.89	0					
D. Tolire	0.949	0.632	0.949	0.378	0.806	0				
Fora	0.828	1.089	0.828	0.964	0.967	0.886	0			
Moya	0.535	0.886	0.535	1.000	0.732	1.000	0.986	0		
Jati	1.000	1.000	1.000	0.906	1.000	0.982	0.824	1.000	0	
Tubo	1.000	1.000	1.000	1.087	1.000	1.151	0.735	0.969	0.601	0

The results of data analysis as in Table 2 show that the Ternate Islands female *Drosophila melanogaster* capture spot has the highest similarity matrix (similarity coefficient) of 0.986%, this can be seen in the Fora and Moya female *Drosophila melanogaster* capture spots. The results of this finding can be interpreted that there is the most similarity in morphological characters. Furthermore, there is the lowest similarity matrix (similarity coefficient) with a percentage value of 0.378%). This can be seen in the female *Drosophila melanogaster* capture spot of Lake Tolire, Dufa-Dufa.

3.1.4. Similarity Matrix of Morphological Characters of Tidore Islands Male Drosophila Melanogaster

Kinship relationships based on matrix similarity analysis (Genetic relationship) and dendrogram analysis show the similarity coefficient of Tidire islands males as in Table 3 below:

Table 3.
Analysis of Similarity Matrix (genetic relationship) of Male Tidore Islands Drosophila melanogaster in 30 Individuals Based on Morphological Characters analyzed by the UPGMA method.

	Rum	**Ome**	**Gurabati**	**Soadara**	**Soasio**	**Afa-afa**	**Topo**	**B.Kusuma**	**Jai**	**Gurabunga**
Rum	0.000									
Ome	1.000	0.000								
Gurabati	1.000	0.853	0.000							
Soadara	1.000	0.782	0.885	0.000						
Soasio	1.000	0.963	0.837	0.992	0.000					
Afa-afa	1.000	0.782	0.785	1.000	0.904	0.000				
Topo	1.000	1.000	0.558	1.000	1.006	0.963	0.000			
Buku K	1.000	0.872	0.876	1.000	1.033	0.806	0.823	0.000		
Jai	0.671	1.000	1.000	1.183	1.000	1.000	1.000	1.000	0.000	
Gurabunga	1.000	0.980	0.753	1.000	0.931	0.922	0.691	0.447	1.204	0.000

The results of data analysis as shown in Table 3 indicate that there are 4 *Drosophila melanogaster* Male capture spots that have the highest similarity matrix (similarity coefficient) of 0.541%. The four fishing that have the highest *similarity coefficient* are Gurabati, Afa-Afa, Topo and Gura Bunga. This result can be interpreted that these four spots have the most similar morphological characters. Furthermore, the lowest similarity matrix (similarity coefficient) is (0.245%) in Tidore Islands *Drosophila melanogaster* found in two capture spots namely Soadara and Soasio capture spots. This result can be interpreted that based on morphological characters, the two fishing spots have little or low similarity.

3.1.5. Similarity Matrix of Morphological Characters of Tidore Islands Female Drosophila Melanogaster

The results of data analysis on the similarity matrix of morphological characters of female *Drosophila melanogaster* of the Tidore islands captured in 10 capture spots show that there is a kinship relationship based on matrix similarity analysis (Genetic relationship) and dendrogram analysis. Furthermore, based on the similarity coefficient of female Tidire islands as in Table 4 as follows:

Table 4.
Analysis of Similarity Matrix (genetic relationship) of Female Tidore Islands Drosophila melanogaster in 50 Individuals Based on Morphological Characters analyzed by the UPGMA method.

	Rum	**Ome**	**Gura bati**	**Soa dara**	**Soasio**	**Afa-afa**	**Topo**	**B.Kusuma**	**Jai**	**Gura bunga**
Rum	0.000									
Ome	0.872	0.000								
Gurabati	0.748	0.730	0.000							
Soadara	0.748	1.000	1.000	0.000						
Soasio	1.000	0.885	0.992	0.967	0.000					
Afa-afa	0.785	0.936	0.586	1.000	0.962	0.000				
Topo	0.649	0.920	0.990	0.833	1.000	1.000	0.000			
B.Kusuma	1.000	1.000	0.980	0.980	0.556	0.785	1.000	0.000		
Jai	0.904	0.918	1.000	0.936	0.852	1.000	0.951	0.866	0.000	
Gurabunga	1.000	0.905	1.000	1.000	0.932	0.822	1.000	0.748	0.988	0.000

The results of data analysis in Table 4 show that there are 3 *Drosophila melanogaster* capture spots that have the highest similarity matrix (similarity coefficient) of 0.510%. The three spots of female *Drosophila melanogaster* capture include Afa-afa, Topo and Gura Bunga spots. These results can be interpreted that the three spots have the most morphological character similarities. Furthermore, the lowest similarity matrix (Similarity coefficient) of 0.180% is found in the spot capture of female *Drosophila melanogaster* spots Rum and Gurabati. This result can be interpreted that based on morphological characters, female *Drosophila melanogaster* has the least similarity.

3.2. Experimental Research Results

3.2.1. The Effect of Research-Based Learning Exploring the Local Potential of the North Maluku Islands on Students' 21st Century Skills on the Concept of Genetic Diversity

3.2.1.1. Description of Data on Improvement of Students' 21st Century Skills Based on Preetest and Postest Results

Data on students' 21st Century Skills were obtained from the results of pretests and posttests or test treatments conducted before and after learning genetic diversity based on research exploration of the local potential of the North Maluku archipelago in experimental and control classes. The results of the analysis are as in Table 5 as follows:

Table 5.
Data Description of Students' 21st Century Skills.

Descriptive Statistics					
	N	**Minimum**	**Maximum**	**Mean**	**Std. Deviation**
21st Century Skills Pretest	43	60.00	70.36	65.0000	3.14683
21st Century Skills Posttest	43	77.50	85.00	80.3410	2.47552
Valid N (listwise)	43				

Based on the results of data analysis as in Table 5, it can be described that the acquisition of the minimum pretest score is 60.00 and the maximum score is 70.00, so that the average score is 65.00. Furthermore, for the posttest value of students' 21st Century Skills, the minimum value is 77.50 and the maximum value is 85.00 with an average value of 80.34. Thus, it can be concluded that the average value obtained by the post-test results is higher than the pretest results. This means that there is an increase in 21st Century skills of class X students of MAN 1 Kota Ternate, after learning by using genetic diversity learning based on research exploring the local potential of the North Maluku archipelago.

The results are also presented in graphical form, as in Figure 1 below:

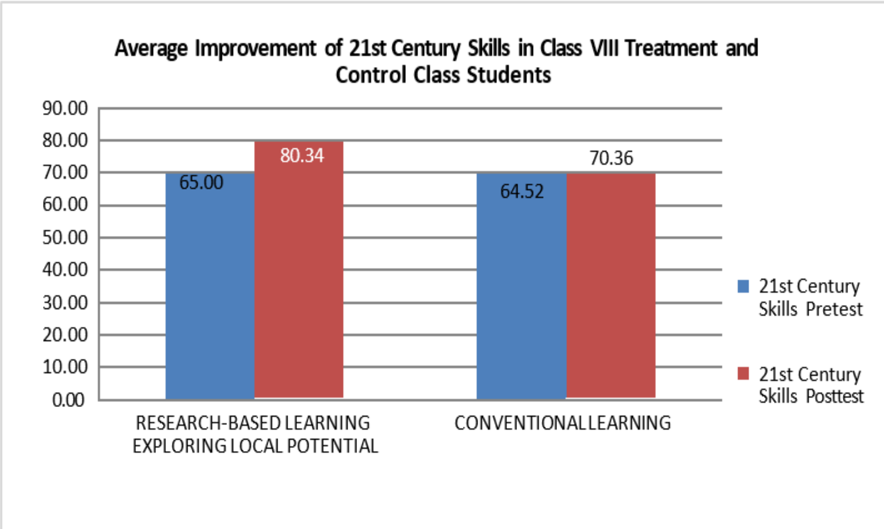

Figure 1.
Graph of Average Pretest and Posttest of Students' 21st Century Skills in Treatment and Control Classes.

Based on the average pre-test and post-test results of MTS SC Ternate students as shown in Figure 1 above, it can be explained that there is an increase in 21st century skills of students after participating in learning genetic diversity based on research exploration of local potential of the North Maluku archipelago.

3.2.1.2. The Effect of Research-Based Learning Exploring the Local Potential of the Archipelago on 21st Century Skills of Class XII Students of MAN 1 Kota Ternate on the Concept of Genetic Diversity

Before the data on the effect of learning genetic diversity based on research exploring the local potential of the archipelago on 21st Century skills of class XII students of MAN 1 Ternate city were analyzed, first the Anakova prerequisite test was carried out, namely the homogeneity test and the data normality test. The results of the prerequisite test analysis showed that all data were normally distributed and homogeneous.

The results of the Anakova test show that there is a significant difference between the 21st Century skills of XII grade students of MAN 1 Ternate city before and after getting genetic learning based on research exploring the local potential of the North Maluku archipelago.

The results of statistical tests on the effect of learning genetic diversity based on research exploring the local potential of the archipelago and conventional learning amounted to 0.03. The results of the data analysis can be interpreted that there is a significant influence on the learning of genetic diversity based on research exploration of the local potential of the archipelago on the 21st Century skills of XII grade students of MAN 1 Ternate city. The results of the analysis are as in Table 6 below.

Table 6.
Hypothesis Test of the Effect of Research-Based Learning Exploring the Local Potential of the North Maluku Islands Wilaya on 21st Century Skills of Class XII Students of MAN 1 Kota Ternate on the concept of Genetic Diversity.

Tests of Between-Subjects Effects					
Dependent Variable:Postes Critical Thinking					
Source	**Type III Sum of Squares**	**Df**	**Mean Square**	**F**	**Sig.**
Corrected Model	402.002[a]	2	201.001	24.538	0
Intercept	336.664	1	336.664	41.1	0
21st century skills	16.466	1	16.466	2.01	0.164
Learning on Genetic Diversity Based on Local Potential Exploration Research	351.585	1	351.585	42.922	0.003
Error	327.65	40	8.191		
Total	250925	43			
Corrected Total	729.651	42			

Note: a. R Squared = .551 (Adjusted R Squared = .528).

Based on the results of the Test of Between-Subject Effects test in Table 6, it can be explained that there is an effect of learning genetic diversity based on research exploring the local potential of the archipelago on students multietnic' 21st Century skills at the level of 0.003, because the sig.<0.05 value, it is stated that H 0 is rejected or the alternative hypothesis is accepted. The results of this hypothesis test can be concluded that learning genetic diversity based on research exploring the local potential of the archipelago has an effect on multietnic students' 21st Century skills and is effectively applied in learning at a significant level of 95% confidence level.

4. Discussion

4.1. Local Potential of Ternate and Tidore Islands in the Form and Color Character of Drosophila Melanogaster

Drosophila melanogaster is commonly known as the fruit fly. Drosophila melanogaster, is one of the most frequently used model organism database in research [30]. The results of observations of morphological characteristics on the color and shape of the eyes of *Drosophila melanogaster* in the Ternate and Tidore islands show that Drosophila melanogaster in the Ternate and Tidore islands have a dark red eye color and one individual in the Ternate islands has a faded eye shape. The results of this study indicate that the shape of the eyes of *Drosophila melanogaster* in the Ternate and Tidore islands has a round and elliptical shape, this is in line with the results of his.

The Drosophila fruit fly eye has a highly organized structure that allows changes to be observed easily, making it an ideal system for genetic screening. The eye consists of about 750 ommatidia that are symmetrically organized and separated by eyelashes.

Marker [31] that the shape of the eye of Drosophila melanogaster is elliptical. According to Buffry, et al. [32] that differences in eye size as well as the number, size, and angle between facets allow for different visual behaviors, lifestyles, and adaptations to various environments.

The characteristics of *Drosophilla melanogaster* found in Ternate and Tidore islands in various capture spots are *Drosophilla melanogaster* characterized by red eyes, elliptical shape, round ellipse. In other findings of research reported by Robert, et al. [33] that *Drosophilla melanogaster* can be characterized by red eyes, round elliptical shape. Furthermore, Robert, et al. [33] also reported in his research that morphological differences are shown in eye color, namely normal *Drosophilla melanogaster* has red eye color, plum strain has dark purple eye color and sepia strain has dark brown eye color. Further explained by his research Iskandar [34] that wild type Drosophila melanogaster has red eyes, sepia type has dark brown eyes and ebony type has a shiny black body.

Evolutionary processes can occur divergently through speciation in initially similar but allopatric populations. It can even happen the other way around. Different species can even mate with each other. For example, in the species Drosophila albomicans and D. nasuta, there is no evidence of sexual isolation between them, and they can even interbreed [35].

Reproductive isolation also depends on the strength of each barrier, so each barrier contributes to the total isolation as a whole [36].

Sexual isolation of one species can allow different species to emerge. This is based on the key definition of species in the biological species concept. This concept emphasizes reproductive sexual isolation, which is the ability of a species to marry each other but no other species [37]. So if a species cannot marry each other / reproduce then it is not a species. Sexual isolation can occur in populations that experience divergent adaptations [38].

The results of this study indicate that in addition to the diversity of *Drosophila melanogaster* eye shape there is also a diversity of abdominal shape, namely the shape of the abdomen found in the Ternate and Tidore islands shows that at the end of the abdomen of male and female *Drosophila melanogaster* is round and pointed. The number of segment lines of male *Drosophila melanogaster* in the Ternate and Tidore islands amounted to 3 lines while the females had 5 segment lines which had a very varied thickness of the segment lines. In addition, the results of this study also show that the thickness of the *Drosophila melanogaster* segment line of the mountainous islands has a thicker segment line than the coastal areas.

As described in the previous section, the results of this study show that the abdominal tip of female Drosophila melanogaster in the capture spots in Ternate and Tidore islands has a rounded and blunt abdominal tip. Another finding was that one individual from the Tidore islands had a mark on the center of its dorsum shaped like a clove fruit. Whether this mark is related to new sepsis, a strain of *Drosophila melanogaster*, or a lethal Drosophila melanogaster is yet to be determined. So further research is needed at the molecular level.

The results of this study are in line with the opinion of Wiyono [39] that to determine male and female *Drosophila melanogaster* can be distinguished based on the number of line segments of the tip of the abdomen and the sex comb, it is seen that the tip of the female abdomen is pointed and the tip of the male abdomen is blunt. Furthermore, according to Hotimah, et al. [40] that there are differences in male and female abdomens, these differences are seen at the end of the male and female abdominal postorior and reproductive organs

Morphological (quantitative) character measurements of *Drosophila melanogaster* in Ternate and Tidore islands. A total of 12 characters from 120 individuals. 60 Ternate Islands individuals (30 males and 30 females) and 60 Tidore Islands individuals (30 males and 30 females). These 12 characters are then processed into ratio data. Measurement of morphological characters (quantitative) based on morphometric parameters (ratio data) Ternate islands have Ternate males varied as many as 6 characters, females varied as many as 8 characters, Tidore males varied as many as 2 characters and Tidore females varied as many as 6 characters

Drosophila melanogaster diversity can be described based on description of color and body shape *Drosophila melanogaster* diversity can also be explained by the description of body size range. Based on the results of research data analysis in Table 4, it can be explained that the body size range of *Drosophila melanogaster* based on morphological characters shows that the female body size range is larger than the male body size. The difference in body size of male and female *Drosophila melanogaster* of Ternate and Tidore islands is in line with the results of research by Rickard [41] and Trmčić, et al. [42] that the body size of female *Drosophila melanogaster* is larger when compared to male body size ranging from ± 2-5mm. but the body size range of *Drosophila melanogaster* of Ternate and Tidore islands is smaller with body range± 2-3 mm.

The results of observations of the body size of *Drosophila melanogaster* Tidore islands have a larger body range when compared to the Ternate islands. This can be explained by environmental factors that greatly affect the body growth of *Drosophila melanogaster*. The results of this study are in line with his research [38] that adaptation to different habitats has caused significant genetic divergence in Drosophila populations. Changes in genes associated with habitat preference and emergence time lead to pre-mating isolation, where flies from different populations rarely meet and mate.

Drosophila melanogaster has become a model organism that is often used in research. With a short life cycle and similar cellular structure to humans, this fruit fly allows researchers to efficiently study the impact of various factors such as stress on neuronal cells. Research by Folarin, et al. [43] and Ibrahim, et al. [44] has demonstrated the potential of Drosophila in uncovering molecular mechanisms underlying neurodegenerative disorders. In addition, it also explains that in using organisms as experiments, the life cycle is something that should not be ignored. The life cycle of flies is important to study to facilitate genetics experiments, observation of development over time, virgin flies, reproduction, breeding, and because they are model animals.

4.2. Local Potential of Ternate City and Tidore Islands in the Form of Genetic Diversity based on Similarity Matrix of Morphological Characters of Drosophila

The results showed that the morphological characters of *Drosophila melanogaster* Ternate and Tidore islands in various capture spots have the least level of similarity. This is reinforced by the data from the UPGM dendrogram cluster analysis that Ternate and Tidore *Drosophila melanogaster* have the least level of similarity. So there is a high diversity in the morphological characters of *Drosophila melanogaster*.

According to Theocharous, et al. [45] and Chen, et al. [8] that morphological variation is one of the factors that influence phenotypic variation at the species level. Drosophila melanogaster variation will appear when analyzed using morphometric studies, there are similarities in each spot, namely spot moya and fora males, Dufa-dufa and Tubo males, bastiong and sulamadaha males and Tolire Lake and sasa males that have similarities, this can support environmental analysis that has similarities.

4.3. Research-based Learning Exploring the Local Potential of the Islands Region on Students' 21st Century Skills on the Concept of Genetic Diversity

Biology learning needs to utilize local potential and scope Suryadarma [16] and Mumpuni, et al. [17] because biology must be relevant to the lives and needs of students. The implementation of learning that utilizes local potential and excellence is possible to improve the ability of content, context, and science processes of students in line with the demands of the 21st century [19]. These efforts must continue to be encouraged, because the number is still limited and uneven [46-48].

The local potential in North Maluku province that can be used as a learning resource needs to be adapted to the demands of 21st century biology learning. The results of this study indicate that biology learning based on exploration of the potential of natural resources in North Maluku, especially on the concept of genetic diversity, can improve the 21st century skills of multiethnic students. According to Fauzi and Ramadani [49] biology learning can be developed by relying on the uniqueness and potential abundance of a region, including local (Traditional) culture and technology. The development of learning tools integrated with local wisdom is expected to develop the potential of each region and improve students' creativity and character. Emphasis on local wisdom as indigenous science in biology learning is considered indispensable. Utilization of local wisdom content in learning, besides being able to save local wisdom knowledge, can also help students in learning biology with real-life learning, which is close to their daily lives. In addition, learning with local wisdom can improve students' relationship with the surrounding community and can connect local knowledge with modern knowledge. This is of course in line with the concept that the expected outcome of learning biology is for students to have science and environmental literacy. This shows that the environmental context cannot be separated in biology learning.

According to Miller, et al. [50] Since the early 20th century, *Drosophila* fruit flies have been a very important model organism in evolutionary biology research. The group is highly studied in many aspects, including life history, phylogeny, ecology, and especially genetics. *Drosophila melanogaster* became a pioneer in genetic research, and now around 500 Drosophila species can be maintained in the laboratory for further study. With complete genomes of many species available, *Drosophila* research offers a solid basis for comparison and experimentation.

Learning activities that tend to be monotonous, only dominated by lectures, minimal practice, and far from the reality of their daily lives will cause students to feel bored. They will also find it difficult to understand the biology material delivered by the teacher. This can certainly have a negative impact on students because the learning objectives and competencies that have been set will not be achieved [51-53]. Learners' unachievement and dissatisfaction with their results should be a challenge for teachers to continuously improve the learning process [54]. In this context, teachers should start looking at and promoting local potential [55]. If learning improvements are not made, it will affect students' concept understanding and subsequently learning outcomes [52, 56, 57].

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