Undergraduate Students' Difficulties in Reading and Constructing Phylogenetic Tree

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Abstract. Representation is a very important communication tool to communicate scientific concepts. Biologists produce phylogenetic representation to express their understanding of evolutionary relationships. The phylogenetic tree is visual representation depict a hypothesis about the evolutionary relationship and widely used in the biological sciences. Phylogenetic tree currently growing for many disciplines in biology. Consequently, learning about phylogenetic tree become an important part of biological education and an interesting area for biology education research. However, research showed many students often struggle with interpreting the information that phylogenetic trees depict. The purpose of this study was to investigate undergraduate students' difficulties in reading and constructing a phylogenetic tree. The method of this study is a descriptive method. In this study, we used questionnaires, interviews, multiple choice and open-ended questions, reflective journals and observations. The findings showed students experiencing difficulties, especially in constructing a phylogenetic tree. The students' responds indicated that main reasons for difficulties in constructing a phylogenetic tree are difficult to placing taxa in a phylogenetic tree based on the data provided so that the phylogenetic tree constructed does not describe the actual evolutionary relationship (incorrect relatedness). Students also have difficulties in determining the sister group, character synapomorphy, autapomorphy from data provided (character table) and comparing among phylogenetic tree. According to them building the phylogenetic tree is more difficult than reading the phylogenetic tree. Finding this studies provide information to undergraduate instructor and students to overcome learning difficulties of reading and constructing phylogenetic tree.

1. Introduction

The main purpose of science education is to develop scientific literacy [1]. One component of science literacy is the ability to represent the phenomenon, the object of events, abstract concepts, ideas, and the mechanism of the system [2], [3]. Representation is an entity in which all thinking is considered to take place, therefore important in the learning process [4]. To really understand the science, students need to know how to interpret, represent and assess scientific claims, all of which implies a fundamental role for representational work [5]. Biologists produce phylogenetic representation to express their understanding of evolutionary relationships.

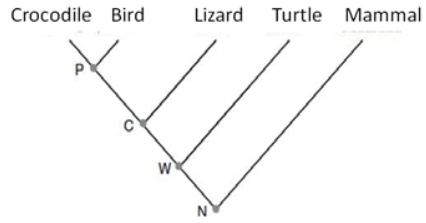
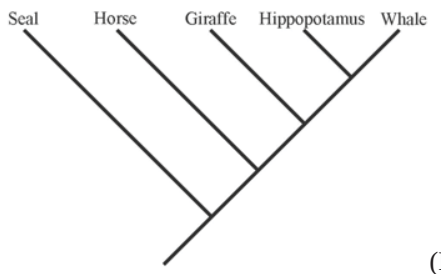
The Phylogenetic tree is visual representation depict a hypothesis about the evolutionary relationship among taxa and widely used in the biological sciences [6], [7], [8]. As visualizations, phylogenetic trees are a type of schematic diagram that illustrates abstract concepts rather than

appearances of objects (iconic diagrams) or quantitative relationships [9]. The ability to read and understand a phylogenetic tree is called tree-thinking [10]. Tree thinking is an important skill for biology students [11]. However, numerous studies indicate that phylogenetic trees are difficult to comprehend for college-level students [12] and students often struggle with interpreting the information that phylogenetic trees depict [13], [14]. The purpose of this study was to investigate undergraduate students' difficulties in reading and constructing a phylogenetic tree. Information obtained from this study can give an idea to educators in developing undergraduate students' skill to reading and constructing phylogenetic trees.

2. Method

The Method of this study is descriptive research. The descriptive research provides information about conditions, situations, and events that occur in the present [15]. The research has been conducted on Program Studi Pendidikan Biologi UIN SGD in Bandung West Java. The subjects in this study were 40 undergraduate students who take vertebrate zoology course in even semester 2016. The instruments used to collect data were questionnaires, interviews, multiple choice and open-ended questions, reflective journals, and observations. All the instruments conduct to reveal undergraduate students' difficulties in reading and constructing a phylogenetic tree. Each question that given to the students are adjusted with tree thinking skill (modification from Novic and Catley [16]), namely describe the character of a taxon from the phylogenetic tree, determine the character of evolution, comparing the type of the phylogenetic tree, applying the concept of clade, Evaluate relative evolutionary relatedness, determine the common ancestor between two or more species (MRCA / Most Recent Common Ancestor) and built a phylogenetic tree. Sample question can be seen in Table 1.

Table 1. Sample Question

No	Indicator	Question
1	Determine the most recent common ancestor (MRCA) between two or more species	 Based on the phylogenetic tree above, the most recent common ancestor (MRCA) of birds and lizards are P, justify that statement? True, because the P position is closest to birds and lizards True, because P developed into C and C developing towards lizard Wrong, because the common ancestor of birds and lizards are C Wrong, because the bird is the common ancestor of crocodiles and lizards Wrong, because the common ancestor does not show in the phylogenetic tree
2	Evaluate relative evolutionary relatedness,	 (Baum, 2005) Observe the phylogenetic tree above, based on the tree Which of these

	statements is true about a giraffe?
	Giraffe more closely related to the horse than with hippopotamus
	Giraffe more closely related to the whale compared with hippopotamus
	Giraffe is closely related to the horse but was not related to hippopotamus
	Giraffe equally related to a hippopotamus and whale
	Giraffe more closely related to the whale compared with hippopotamus

3. Result and Discussion

Results of questionnaire to the students revealed can be seen in Table 2. and Figure 1.

Table 2. Students' Responses to the Difficulties in Read and Construct a Phylogenetic Tree

Question: Which do you think is the most difficult of the following matters relating to the phylogenetic tree?	
Indicator	Students' Responses
Describe the character of a taxon from the phylogenetic tree	10%
Determining the character of evolution	43%
Comparing the type of the phylogenetic tree	38%
Applying the concept of clade	10%
Evaluate relative evolutionary relatedness	29%
Determining the Most Recent Common Ancestor between two or more species	5%
Construct a phylogenetic tree	86%

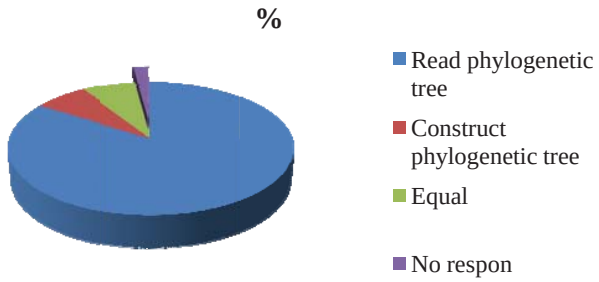


Figure 1. The Percentage Students' Responses to The Question "According to You, Which One is Easier to Read or Construct Phylogenetic Tree?"

Based on Table 1 and Figure 1, an interview and reflective journal, the students stated that constructing the phylogenetic tree was more difficult than reading the phylogenetic tree. The students' responses indicated that main reasons for difficulties to constructing phylogenetic tree are difficult to placing taxa in a phylogenetic tree based on the data provided because they are still confused to determining the sister group from the character table. Thus, the phylogenetic tree that is made does not describe the actual evolutionary relationship (incorrect relatedness). Students also have difficulties in determininig character synapomorphy, autapomorphy from character table. According to them, the more taxa and characters presented in a table of characters, the more difficult to construct a phylogenetic tree. The result of student responses, not much different from previous studies that tree building is more conceptually difficult and builds upon tree reading skills [14].

Percentage of students who answered correctly in each of the questions in the tests related to reading the phylogenetic tree shown in Figure 2.

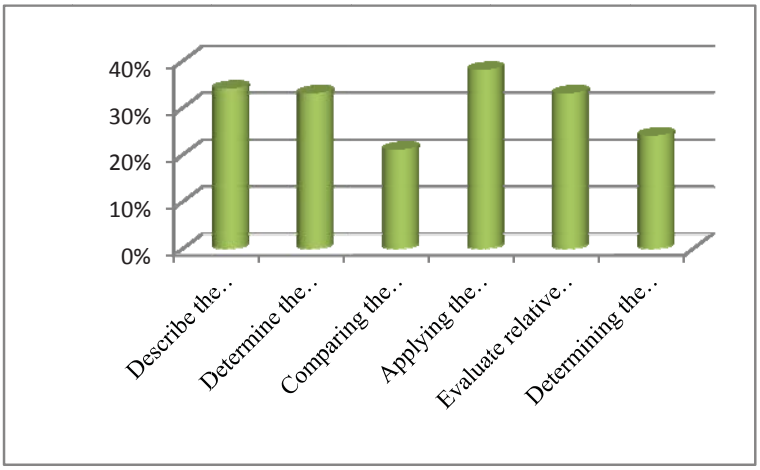


Figure 2. Percentage of students who answered correctly in each of the questions in the tests related to read phylogenetic tree

Based on Figure 2, it appears that the students' ability to read the phylogenetic tree is low, as well as the students' ability to construct a phylogenetic tree. Some reasons have given student-related difficulties in reading phylogenetic tree included (1) If taxa and characters presented in the phylogenetic tree in large number; (2) if the phylogenetic tree is given in ladder format, because students had much greater difficulty understanding the ladder than the tree format (Figure 3.); (3) they forgot about synapomorphy, autapomorphy, so often confused.

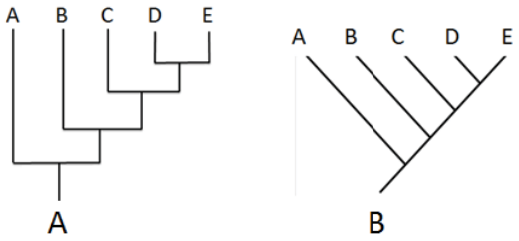


Figure 3. Tree Format (A) Ladder Format (B)

Understanding a phylogenetic tree is not an easy thing. The researcher has an opinion that understanding phylogenetic tree is a complex cognitive task and without proper scaffolding, many students can't transfer the empirical data into visual structure [17]. So that students can read and construct a phylogenetic tree such as an expert, the student must understand the structure of the phylogenetic tree, the mechanism of evolution, inheritance, and genomics [2]. Students also need to continue the practice in reading and building the phylogenetic tree.

4. Conclussion

Based on this study concluded that undergraduate students having difficulties in reading and constructing a phylogenetic tree, such as determining the sister group, character synapomorphy, autapomorphy from data provided. According to them, building the phylogenetic tree is more difficult than reading the phylogenetic tree. Thus, it would appear that there is a strong necessity to find a suitable strategy to cover most of these difficulties for improving students in reading and constructing a phylogenetic tree. The result of this study will help educator and researchers to design learning techniques to overcome the mentioned difficulties.

5. References

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