



# Development of ICT-Based Teaching Materials on Phylogeny Topic as Innovations in Evolution Courses: A need analysis

Akram<sup>1</sup>, Ixora Sartika Mercuriani<sup>2\*</sup>

<sup>1</sup> Master of Biology Education Study Program, Faculty of Mathematics and Natural Science, State University of Yogyakarta, Yogyakarta Indonesia.

<sup>2</sup> Biology Education Study Program, Faculty of Mathematics and Natural Science, State University of Yogyakarta, Yogyakarta Indonesia.

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Corresponding Author:

Ixora Sartika Mercuriani

[ixomerc@uny.ac.id](mailto:ixomerc@uny.ac.id)

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**Abstract:** This study aims to collect and analyze the data needed for the development of ICT-based teaching materials in evolution courses on phylogeny topic. The methods used are systematic reviews and surveys. Based on the results of a systematic review, it can be concluded that the trend of research on evolution courses on phylogeny topic in scientific articles published in 2015-2021 is the mastery of tree thinking skills. The teaching materials developed to support the mastery of tree thinking skills are booklets, modules, and game cards. Based on the results of the survey, it can be concluded that the majority of students prefer to use smartphones instead of laptops to find and study evolution lecture materials and only a small percentage of students who have obstacles to accessing the internet both in the classroom and outside campus. The highest percentage of electronic teaching materials that students like the most are more diverse teaching materials. This need analysis provides information that can be used to develop ICT-based teaching materials on phylogeny topic.

**Keywords:** ICT; Phylogeny; Need analysis.

## Introduction

The integration of ICT into learning has become a necessity for the realm of education in various countries including Indonesia (Hafifah & Sulisty, 2020; Mahdum et al., 2019). It is undeniable that ICT has a positive impact on student learning outcomes (Arpacı et al., 2021; Srijamdee & Pholphirul, 2020). Drayton et al. (2010), argue that the integration of ICT into the teaching and learning process has the advantage of increasing the motivation, involvement and productivity of students. Furthermore, according to Drayton et al. (2010), learners have many opportunities to collaborate, explore and experiment with the help of ICT. The integration of ICT into the learning process can provide positive changes to the academic achievement, critical and creative thinking ability of students (Yilmaz, 2021). In addition, the use of ICT can improve teachers' ability to teach so that effective and enjoyable learning can be realized (Kingsley, 2017; Tzafilkou et al., 2021).

Information and communication technologies (ICT) is an innovative tool for teachers and lecturers because various studies show that innovative products that use ICT have been used to improve the learning and teaching experience to be better (Almusawi et al., 2021). However, the success of such innovation depends on the way the teacher develops his pedagogical abilities and utilizes the available ICT (Albion et al., 2015; Vincent-Lancrin et al., 2019). What is also important is that teachers need to have the ability to design and implement appropriate instructional systems (Creese et al., 2016). Apart from the various challenges encountered by teachers, efforts to innovate in learning need to be made.

Individual factors such as investing time and effort to study regularly, setting learning goals and having the ability to organize learning independently, are factors that have contributed to changes in deep approaches to learning in different learning environments for students (Postareff et al., 2015). However, learners who are still conventional, will cause students to be less interested in

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learning so that it has an impact on learning outcomes (Cheah, 2020; Zhang et al., 2013). This can be influenced by the use of teaching materials and learning models that have not utilized ICT optimally (Saputro et al., 2021). Another effect that can be caused is that students will have difficulty in understanding and designing research (Muskiti et al., 2020). Therefore, innovation in the form of developing teaching materials that are integrated with ICT is important to prioritize.

To develop effective and appropriate teaching materials, conduct a needs analysis first (Nastiti et al., 2018; Ardianti et al., 2019). Needs analysis is the initial research in developing learning products in various researches with research and development (R&D) design (Kusumawardani et al., 2020; Subali, 2017; Febrian et al., 2021). According to Wirjawan et al. (2020), needs analysis is carried out by examining the need for teaching materials obtained from educational institutions, teachers and students, as well as information about the curriculum used. A needs analysis is also carried out to identify problems in the field (Widarti et al., 2020). These problems can be related to inappropriate learning arrangements, students' suboptimal high-level thinking skill and the lack of use of innovative technology (Lee, 2019). In addition, needs analysis can also be done through systematic review, namely the study of scientific articles (Pipattanasuk & Songsriwittaya, 2020). The needs analysis results can be used as the primary reference for developing the product and its specifications

Evolution is a branch of biological science that investigates the process of biological change in which each species accumulates character differences obtained from their ancestors as they adapt to different environments over time (Urry et al., 2020). As for phylogeny, it is the study of the evolution history of a species or group of species visualized through phylogenetic trees (Solomon et al., 2019). Sa'adah et al. (2017) & Fuadiyah et al. (2021) revealed that the majority of students have difficulty understanding phylogeny, which is based on the low ability of students to interpret phylogenetic trees so that the right solution is needed to overcome this problem.

The development of ICT-based teaching materials is one of the solutions to make it easier for students to understand phylogeny topic and need analysis is a very important initial stage in developing such teaching materials. The results of the needs analysis in this research can be used as a basis for designing appropriate and effective ICT-based teaching materials to improve students' cognitive abilities in learning phylogeny topic. In addition, the results of the needs analysis in this research can also be used as a reference to develop ICT-based teaching material products on various other topics in evolutionary courses. Based on the various explanations above, this research aims to collect and

analyze the data needed for the development of ICT-based teaching materials in evolutionary courses on phylogeny topic.

## Method

This research is included in the scope of descriptive research (Nastiti et al., 2018; Widarti et al., 2020). There are 2 main stages in this study, namely systematic review and survey. The research flowchart is illustrated in Figure 1.

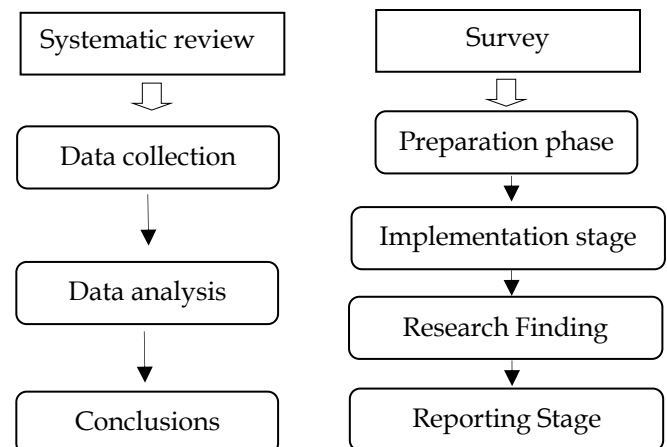


Figure 1. Research flowchart with systematic review and survey method

Systematic review is a systematic and explicit method to identifying, selecting and critically assessing relevant research as well as for collecting and analyzing data from research included in the review (Moher et al., 2009; Cremin & Chappell, 2019). This stage aims to find out the research trends and teaching materials used in courses on phylogeny topic by referring to articles that have been published. The systematic review procedure follows Juandi, (2021) namely data collection, data analysis and conclusion of analysis results. The data source comes from the data base of electronic journals indexed by SCOPUS, SINTA and ERIC as well as other reputable data bases. The instrument used is a selection sheet for scientific articles related to inclusion criteria. The inclusion criteria include research published in the 2015-2022 period, including research in the field of biology education at the S1 level and research in studies on phylogeny topics.

The second stage is a survey. Survey research is characterized by the existence of a self-report, namely that the party being studied reports his condition based on a kind of data collected by the researcher (Subali, 2017). This stage aims to obtain information related to the needs of student teaching materials including assumptions related to the use of electronic devices, Internet and the need for electronic teaching materials. The survey procedure for this needs analysis follows

Widarti et al. (2020) namely Preparation (research planning and making online questionnaires), implementation (dissemination and filling out questionnaires online), Research results (analyzing results and making conclusions) and reporting. The subjects of the study were 91 students who had programmed the evolution course. All research subjects came from the biology education study program of Tadulako University which was determined using the quota sampling technique. The instrument used is in the form of a close ended questionnaire. The data obtained were later analyzed using Microsoft Excel 2019.

## Result and Discussion

### Systematic review

Sixteen articles meet the inclusion criteria in this systematic review, which are presented in Table 1. The various article provides information related to learning on phylogeny material at the S1 level. By following research trends and the types of teaching materials developed, researchers and lecturers can obtain a lot of literature that can be used in the development of ICT-based teaching materials.

Based on table 1, Mastery of tree thinking skills is a trend for each scientific article in the field of biology education in the study of phylogeny published in 2015-2021. The list of scientific articles provides a variety of information on misconceptions, learning tools, data collection instruments, and appropriate learning designs to optimize tree thinking skills. A phylogenetic tree is a diagram that represents the phylogeny of living beings and tree thinking is a cognitive ability needed to interpret the diagram (Dees et al., 2014).

**Table 1.** List of scientific articles that meet the inclusion criteria

Research title	Research Type	Journal Name	Source
Correlations between Tree Thinking and Acceptance of Evolution in Introductory Biology Students.	Quantitative	Evolution: Education and Outreach	(Gibson & Hoefnagels, 2015)
A valid assessment of students' skill in determining relationships on evolution trees	Quantitative	Evolution: Education and Outreach	(Blacquiere & Hoese, 2016)
Prevalence and Persistence of Misconceptions in Tree Thinking	Quantitative	Journal Of Microbiology & Biology Education	(Kummer et al., 2016)
Student construction of phylogenetic trees in an introductory biology course	Quantitative	Evolution: Education and Outreach	(Dees & Momsen, 2016)
Fostering 21st-Century Evolution Reasoning: Teaching Tree Thinking to Introductory Biology Students	Quantitative	CBE—Life Sciences Education	(Novick & Catley, 2016)
Botanical Phylo-Cards: A Tree- Thinking Game to Teach Plant Evolution	Quantitative	The American Biology Teacher	(Gibson & Cooper, 2017)
Undergraduate Students' Initial Ability in Understanding Phylogenetic Tree	Quantitative	Journal of Physics: Conference Series	(Sa'adah et al., 2017)
Effects of Phylogenetic Tree Style on Student Comprehension in an Introductory Biology Course	Quantitative	The American Biology Teacher	(Dees et al., 2017)
Further effects of phylogenetic tree style on student comprehension in an introductory biology course	Quantitative	CBE—Life Sciences Education	(Dees et al., 2018)
Teaching tree thinking in upperlevel organismal biology course: testing the effectiveness of a multifaceted curriculum	Quantitative	Journal of Biological Education	(Novick & Catley, 2018)
Untangling the contribution of characters to evolution relationships: a case study using fossils, morphology, and Genes	Quantitative	Journal of Biological Education	(Whitenack & Drew, 2019)
Development of an Evolution Tree Concept Inventory	Quantitative	Journal Of Microbiology & Biology Education	(Kummer et al., 2019)
Exploratory Activities for Understanding Evolution Relationships Depicted by Phylogenetic Trees: United but Diverse	Quantitative	The American Biology Teacher	(McCullough et al., 2020)
The Effects of Invention and Recontextualization on Representing and Reasoning with Trees of Life	Mix method (qualitative and quantitative)	Research in Science Education	(Matuk & Pronunciation, 2020)
Using Project-Based Learning to Teach Phylogenetic Reconstruction for Advanced Undergraduate Biology Students: Molluscan Evolution as a Case Study	Quantitative	The American Biology Teacher	(David, 2018)
Cladogram misreading of undergraduate students in understanding evolution	Quantitative	Jurnal Pendidikan Biologi Indonesia	(Fuadiyah et al., 2021)

Based on Table 1, tree thinking skills is a trend for each scientific article in the field of biology education in the study of phylogeny published in 2015-2021. The list of scientific articles provides various information on misconceptions, learning tools, data collection instruments, and appropriate learning designs to optimize tree thinking skills. A phylogenetic tree is a diagram representing the phylogeny of living beings, and tree thinking is a cognitive ability needed to interpret the diagram (Dees et al., 2014).

In addition to knowing the trends of the latest research on phylogeny, this Systematic review also reviews teaching materials that have been developed. Of the 16 articles above, there are 4 articles that include the use of teaching materials in courses and are presented in table 2. Each of these teaching materials is developed to support the mastery of tree thinking skills that are integrated with certain learning designs.

**Table 2.** List of scientific articles that include teaching materials to support mastery of tree thinking skills

Research title	Teaching materials	Source
Fostering 21st-Century Evolution Reasoning: Teaching Tree Thinking to Introductory Biology Students	Booklet	(Novick & Catley, 2016)
Botanical Phylo-Cards: A Tree- Thinking Game to Teach Plant Evolution	Botanical Phylo-Card Game	(Gibson & Cooper, 2017)
Teaching tree thinking in upperlevel organismal biology course: testing the effectiveness of a multifaceted curriculum	Booklet	(Novick & Catley, 2018)
Exploratory activities for understanding Evolution Relationships Depicted by Phylogenetic Trees: United but Diverse	Modul <i>tree thinking</i>	(McCullough et al., 2020)

Based on Table 2, there are three types of teaching materials that have been developed related to phylogeny topic, namely booklets, modules and game cards. The booklet is a relatively thin book, the content is complete, the material is short and easy to carry (Syamsurizal et al., 2021), while the module is an instructional package with one integrated theme, providing the information needed to develop mastery of certain knowledge and skills and designed for self-learning (Branch, 2010). The game card is a collection of cards containing specific material intended for game-based learning (Singh et al., 2021). The booklet designs, modules and game cards available above can be used as a reference for the development of ICT-based teaching materials both from the aspects of media, materials and learning.

The low mastery of tree thinking skills results in students misinterpreting phylogenetic trees (Meir et al., 2007; Novick & Catley, 2013). This can have an impact on the low mastery of learning outcomes that have been targeted at phylogeny topic. Although the various studies above have presented information about instruments, teaching materials, and learning designs to make it easier for students to master tree thinking skills, it is only can be applied to favorable situations and conditions. Therefore, various innovations in courses, especially the development of ICT-based teaching materials, are one of the solutions to complement existing data so that lecturers have a variety of alternative teaching materials that can be used according to the situation and conditions encountered.

*Survey*

The results of filling out questionnaires by 91 students related to the need for teaching materials for

evolution courses on phylogeny materials can be seen in tables 3 and 4. Table 3 presents student responses regarding the use of electronic devices and the internet consisting of 4 questions. Table 4 presents the response to the needs of teaching materials consisting of 6 questions.

The questions asked to find out the assumptions of students regarding the use of electronic devices and the internet aim to make researchers obtain information about electronic devices that are more widely used and the availability of access internet while studying evolution material. Based on Table 3, data was obtained that the majority of students prefer to use smartphones instead of laptops to find and study evolution lecture materials. This shows that the development of teaching materials that are effective and make it easier for students to learn should use a platform that can be accessed using a smartphone instead of a laptop. However, teaching materials that can be accessed at once by both devices can also be a solution to make it easier for students to master the material taught optimally. Another information obtained is that only a small number of students have problems accessing the internet both in class and outside campus so that students are easy access the materials presented online. Based on the explanation above, it can be seen that the development of ICT-base teaching materials in evolution courses on phylogeny material is very potential to be carried out because the means that students have are very supportive.

**Tabel 3.** Responses related to the use of electronic devices and Internet

Question	Answer Percentage	
	Already	Do not
Has your smartphone used for searching information and studying about evolution optimally	93.3%	6.67%
Has your laptop used to find and study material in evolution courses optimally	76.7%	23.3%
Do you have problems with the internet network during learning	31.1%	68.9%
Do you have problems related to the internet network when you are outside campus?	37.8%	62.2%

Smartphones, laptops and internet availability are important components in ICT that determine learning success (Owen et al., 2020). Smartphones and laptops can facilitate communication between students and access to information to various learning resources provided on the internet (Vahedi et al., 2021). The development of software-based teaching materials accessed using smartphones has been widely carried out, including by Aminatun, et al., (2022), Firdawati et al., (2021), Nabella & Dwiningsih, (2022), and Susanto et al., (2022). The development of website-based teaching materials that can be accessed using laptops and smartphones has also been widely carried out, among others, by Prabowo et al., (2020), Hariadi et al., (2022), Miswami - Nurcahyo, (2020) and Hidayah et al., (2018).

The questions asked to find out students' assumptions regarding the need for electronic teaching materials aim to make researchers obtain information about teaching materials that students like the most in understanding evolution materials. Based on Table 4, it can be known that the highest percentage for the most preferred teaching materials is more diverse. This shows that the use of diverse teaching materials has the potential to improve student learning outcomes in evolution courses, especially in phylogeny topic. The right design of teaching materials can increase interest and make students active in learning so that the targeted learning outcomes can be met.

**Table 4.** Assessment of electronic teaching material need

Question	Answer Percentage (%)	
	Already	Do not
Do you prefer to learn directly from e-books?	68.90	31.10
Do you prefer to learn directly from scientific articles/journals?	56.70	43.30
Do you feel clearer if the teaching materials used are PPT-based?	80.00	20.00
Do you feel clearer if the teaching materials used are video-based?	90.00	10.00
Do you feel clearer if the teaching materials used are e-module-based?	55.60	44.40
Do you feel clearer if the teaching materials are more diverse (e-books, videos, pictures, etc.)	97.80	2.20

Types of electronic teaching materials that are widely used include power points, videos, E books, e modules and others. The electronic teaching materials are based on pdf or software. Ppt (power Point) is used to prepare slides in a more interesting and effective way that includes the integration of multimedia elements such as text, graphics, animation, and video (Osman et al., 2022). Video is used to blend verbal instructions with visual images (Castillo et al., 2021). E books are used to provide teaching materials that have features of text search, text highlighting, creating notation and marking pages (Lim et al., 2020). The E module is used as teaching material written with the aim that students can learn independently without the guidance of the teacher (Sofyan et al., 2019). The design of ICT-based teaching materials can accommodate the various features possessed by the various teaching materials above so that student learning outcomes on phylogeny topic can be improved Optimal.

**Conclusion**

Referring to the result of the systematic review, it can be concluded that the research trend of evolution

courses on phylogeny topic based on scientific articles published in 2015-2021 is the mastery of tree thinking skill. The teaching materials developed to support the mastery of tree thinking skills are booklets, modules and game cards. Based on the results of the survey, it can be concluded that the majority of students prefer to use smartphones instead of laptops to find and study evolution lecture materials and only a small percentage of students who have obstacles to accessing the internet both in the classroom and off campus. In addition, the highest percentage of electronic teaching materials that students like the most is more diverse teaching materials. This need analysis can be used as a basis for developing ICT-based teaching materials as an innovation in evolution courses to make it easier for students to learn phylogeny topic.

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