

## Improving Students' Cognitive Understanding of Natural Selection Topics Through PhET Simulations

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**Abstract:** Natural selection is one of the topics of evolution material that is considered difficult for students, so it is necessary to have a practicum to help in understanding this material. Limited laboratory equipment in schools is an obstacle to learning evolution, so learning media are needed to support evolution learning. One of the learning media that can be applied is PhET simulation. PhET simulation supports evolution learning because it provides simulations in the form of processes of how living things experience natural selection mechanisms. This service program aims to describe students' cognitive understanding of the topic of natural selection with the help of the PhET simulation application. This activity is expected to be used as reference material for teachers who conduct practicums with the help of the PhET simulation application. The subjects who participated in this service activity were 30 students in class XII MIPA. The service activities were carried out on June 16–23, 2023, at SMAN 4 Tuban. The service activities carried out include training, discussion, and guidance. Based on the results of the program, it can be seen that the trainees were very enthusiastic about participating in the PhET simulation activities, the use of PhET simulation was easy to apply, and the trainees were easier to understand the material with the help of this application (87% of the time).

**Keywords:** cognitive understanding; evolution; natural selection; PhET simulation

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### INTRODUCTION

Evolution is considered a significant branch of biology. Evolution is not typically explained in detail at the high school level because its pure theories predominantly dominate it. Evolution, the science that deals with the history of the development of living organisms, is widely perceived as an integral part of the latest information discourse on a subject. Previous researchers have noted

that science teachers sometimes feel uncomfortable addressing pedagogical topics similar to evolution due to its social controversy. Many of them are hesitant to offend students potentially, or they may not align with the views of their parents or even the administration under which they work (Owens et al., 2017). This is consistent with earlier research reporting that conflicts in evolutionary theory, also found by many

researchers, are not only based on differences in beliefs (religion) but fundamentally arise from the difficulty of the material for teachers to teach in schools due to their abilities and knowledge capacities (Bauto, 2014; Saputra, 2017; Suwarjono, 2019). One of the topics covered in the evolution curriculum is natural selection.

Natural selection is a process whereby organisms can survive to the present day because they can adapt to their environment or habitat (Gulizzza, 2014; Offer, 2014). Natural selection has been occurring since ancient times, and there are many examples of natural selection that have led to the extinction of some species and the emergence of new species. Teaching natural selection in high school is generally supported by something other than practical activities. This is due to the limitations of laboratory equipment in those schools. Practical activity is essential to support the material being taught. However, not all schools have well-equipped laboratories for practical activities, such as SMAN 4 Tuban. In this school, teachers provide natural selection material using textbooks and reference books. This was observed by the community service team from UNIROW Tuban during their visit to the school. However, in the theory of natural selection, many concepts need to be understood. The limitations of facilities in schools will impact students' understanding, especially in cognitive aspects.

Cognitive understanding is essential in the field of education. It is one of the three aspects evaluated in learning activities. Cognitive-conceptual understanding can be obtained through more meaningful learning activities where students must remain active and not just passively receive information from the teacher. Instead, they become active subjects who engage in thinking processes such as searching, analyzing,

reducing, combining, speculating, and solving problems. Based on the theory of epistemological reality, there is an emphasis on the need for a learning environment that provides various opportunities for students to develop and create knowledge based on their experiences. Learning experiences are gained, in part, through direct practical activities. Additionally, the environment also impacts learning activities, such as cognitive styles. Cognitive style refers to the disparity in how individuals process received information. Learning styles include visual, audiovisual, and kinesthetic; thus, efforts are needed to enhance students' understanding.

One solution to assist teachers in teaching evolution to students is utilizing computer technology. The advancement of technology has brought innovation to learning, particularly in biology. Some technologies can be used as efficient and effective simulation laboratory media. One dream simulator that can be utilized is the Physics Education Technology (PhET) simulation. PhET refers to simulations created by the University of Colorado, containing physics, biology, and chemistry learning simulations for classroom or direct learning purposes. PhET simulations emphasize the correlation between concrete life phenomena using basic science, support interactive approaches and feedback, and provide innovative resources. Thanks to this medium, practical activities can be simulated virtually, saving time and resources without compromising the objectives of the practical activity (Astuti & Handayani, 2018). In essence, practical activities bridge theoretical concepts and actual related facts, which can be simulated through interactive platforms (Bhakti & Napis, 2018). Based on this collaborative conflict, the dedication to the community is conducted to describe students' cognitive understanding of the

natural selection topic using the PhET simulation application.

## METHOD

The method used is participatory action research (PAR). This activity was carried out at State Senior High School 4 Tuban, in Tuban Regency. The dedication took place from June 16th to June 23rd, 2023. The implementation time was during school hours, from 08:00 to 12:00 WIB. The training participants were 30 students from class XI IPA, selected representatives from each class with the hope that they would later disseminate the knowledge to their respective classmates. The tools and materials used in this activity included a projector, LCD, laptop, smartphone, and PhET simulation worksheets. The method offered to address the partner's issues was providing materials and training. After participating in the training activities, participants received guidance in conducting PhET simulations.

The method used generally consists of three stages: preparation, implementation, and evaluation, as outlined in Figure 1.

1. Preparation Stage: In this stage, the community service team visits the location to analyze the partner's issues, designs the activities to be carried out, and develops instruments such as worksheets.
2. Implementation Stage: During this stage, the community service team delivers lectures on natural selection, followed by training using PhET simulation media aimed at students of SMAN 4 Tuban. This activity aims to enhance students' understanding and potentially serve as an alternative practical activity.
3. Evaluation Stage: The community service team evaluates the activities in this stage. Evaluation begins with the preparation stage, including partner needs analysis, preparation, and validation of worksheets, and

extends to the implementation stage, including participant attendance, responses, and feedback on the activities. The activities in this stage include assessing the cognitive improvement of the students as observed through the learning process and student response questionnaires.

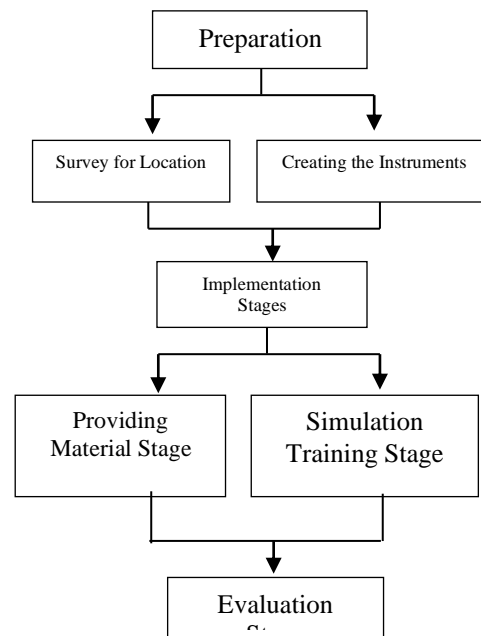


Figure 1 Civil service method

## RESULT AND DISCUSSION

The activity begins with the facilitator presenting material, which provides initial knowledge and understanding of evolutionary concepts, specifically focusing on natural selection, as depicted in Figure 2.



Figure 2 Delivering material on natural selection

After the material presentation, one of the instructors guided the students in using the PhET simulation application with the assistance of the developed worksheets. This community service utilizes a guided inquiry learning model to provide students with more directed learning. Subsequently, students are encouraged to use their smartphones in simulation activities or practices. Both students and instructors accompany the students during this activity, assisting if any difficulties arise, as illustrated in Figure 3.



Figure 3 Training on the use of PhET simulation application

Based on Figure 3, it is evident that the training participants are actively engaged in the activity. The participants are divided into six groups to facilitate guidance, and all participants operate their smartphones to apply the PhET simulation. Each group is accompanied by a member of the community service team, with the hope that students can easily follow this activity. Additionally, this can also influence students' cognitive understanding. Research supporting this statement is also tested by (Azizaturredha et al., 2019), which explains that learning, scientific process skills, and student learning motivation can increase using PhET and guided inquiry education examples. Guided inquiry education can create student knowledge based on personal experiences using PhET simulation media (Budi et al., 2021; Fithriani et al., 2016; Mahtari et al., 2020; Maulani et al., 2018). These findings are reinforced by the survey obtained during the coaching sessions, as shown in Figure 4.

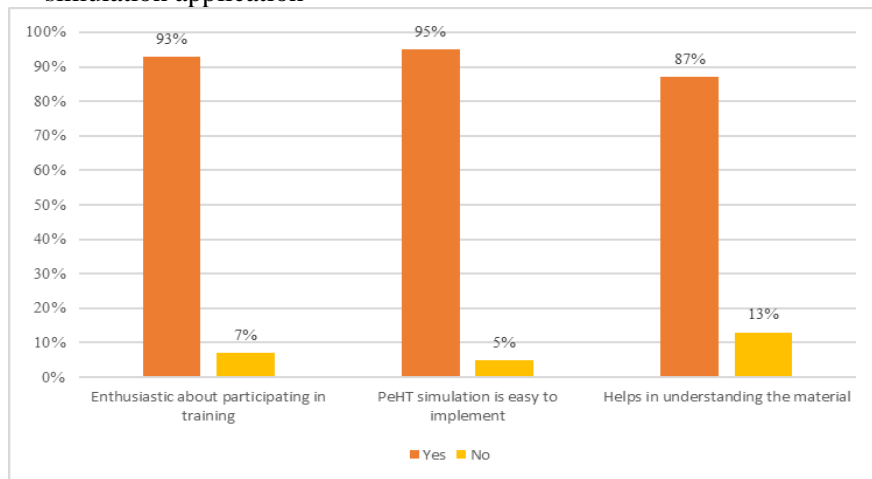


Figure 4 Student response questionnaire

Based on Figure 4, it can be seen that 93% of students are enthusiastic about participating in this training activity. This is because the media presentation has an interesting and captivating appearance, attracting the attention of students and increasing learning

motivation. This is in line with the research by Muzana et al. (2021), which found that using PhET simulations results in students being more active and enthusiastic in exploring learning because PhET simulation media has a good and attractive appearance.

Another indicator also states that PhET simulations are easy to implement, with a percentage of 95%. This is due to the worksheets the Community Service team prepared, which make it easier for students to apply PhET simulations. Additionally, with visual media, students actively represent the worksheets they are learning. During the training activities, students actively seek knowledge and cooperate with fellow students throughout the learning process. This is consistent with the research by Laila (2020), which proves that implementing STEM-based virtual laboratories can improve problem-solving skills. These problem-solving skills are students' abilities to create solutions using methods of receiving and organizing data through dream laboratory media in the form of PhET simulations.

PhET simulations can also help students understand the material by 87%. This means that students' cognitive understanding increases. This is consistent with the research by Mubarrok (2014), which states that PhET simulations can increase students' understanding of concepts in light. Furthermore, Aprilia (2020) stated that using PhET simulation media in distance education using Zoom can enhance the higher-order thinking Skills (HOTS) of high school students of different types. Based on the learning conducted, students require less time to understand the material in the presence of simulations. This is consistent with Maulina (2017), who found that learning using PhET media is more efficient in software than just concrete practicals.

## CONCLUSION

Based on the results of the community service activities conducted at SMAN 4 Tuban, it can be concluded that students have a high level of enthusiasm when participating in this activity. Participants

can easily apply this PhET simulation medium with the assistance of worksheets provided by the community service team. This positively impacts students' cognitive understanding, as students express that the presence of this medium makes it easier to understand the material. Looking ahead, the hope is that this activity can be followed up with different topics, with the aim of addressing issues that occur in schools.

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