

# HOTS Analysis to Develop E-Supplement Book Based on Plant Physiology Research

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Received October 30, 2020; Revised November 28, 2020; Accepted December 22, 2020

## Cite This Paper in the following Citation Styles

(a): [1] Supriyatin, Nailul Rahmi Aulya, Ilmi Zajuli Ichsan, Md. Mehadi Rahman, Paulo Weslem Portal Gomes, "HOTS Analysis to Develop E-Supplement Book Based on Plant Physiology Research," *Universal Journal of Educational Research*, Vol.8, No.12B, pp. 8461-8466, 2020. DOI:10.13189/ujer.2020.082654.

(b): Supriyatin, Nailul Rahmi Aulya, Ilmi Zajuli Ichsan, Md. Mehadi Rahman, Paulo Weslem Portal Gomes (2020). *HOTS Analysis to Develop E-Supplement Book Based on Plant Physiology Research*. *Universal Journal of Educational Research*, 8(12B), 8461-8466. DOI:10.13189/ujer.2020.082654.

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**Abstract** Biology learning, especially the topic of plant physiology, requires Higher Order Thinking Skills (HOTS). This ability needs to be improved with HOTS-based teaching materials. The teaching materials, however, have not been developed, especially those in plant physiology topic. Students' HOTS in biology learning still requires an improvement as HOTS is important for the 21st century. One alternative that can be developed is teaching materials in the form of an E-Supplement Book Based on Plant Physiology Research (ESPPRe). The purpose of this study was to measure students' HOTS related to the concept of plant physiology as the basis for developing ESPPRe. The method used was descriptive using a survey technique. The instrument used in this study amounted to 10 items distributed using Google form. The results indicated that the scores were categorized as low for all students (40.81) with male students (41.39) and female students (40.74). This suggested that the HOTS score still needs to be improved and it is necessary to develop ESPPRe in further research. The content on the ESPPRe media that must be developed is related to activities to analyze and criticize problems that have been presented in ESPPRe. Next, students are expected to be able to create solutions and ideas related to these problems. The development of various learning media will make students happier in learning. This is because HOTS-based learning implementation will be varied. This study

concludes that the HOTS score is still in the low category and the ESPPRe can be developed in subsequent studies. Suggestion from this research is to be able to implement the book to improve students' abilities to solve problems.

**Keywords** ESPPRe, HOTS, Plant Physiology, Supplement, Students

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## 1. Introduction

Biology education in the 21st century requires various learning innovations. One of the current learning innovations is a supplement book. This is related to the fact that there are still limited sources of books that are adequate for developing student insights and contain applicative material. Textbooks often contain subject matter that is generally explained yet relatively few little additional explanations included in the learning topics related to plants. The primary learning resources used in classrooms are textbooks and student worksheets. Textbooks in schools are full of textual explanations on a concept of matter, lack of images as well as low quality of images, general examples, and less contextual for students. Learning resources in schools are insufficient as there are lacks of plant topics. In addition, teachers rarely develop

any teaching materials for students [1]. Students do not understand many topics at school. Moreover, the materials presented sometimes do not follow the current context. Consequently, the materials in learning are difficult to apply in everyday life context [2–6].

One material that is difficult to study is related to physiological processes in plants. This topic is important to discuss because it will lead students to understand various processes occur in plants. Knowledge of the physiological process becomes essential to learn contextually. Several previous studies examined the development of teaching materials for students [7]. The results of the teaching materials development were implemented in class and it showed an increase in results [8]. Teaching aids or materials are very important for students to learn different concepts of science [9]. This shows that textbooks have a role in improving students' Higher Order Thinking Skills (HOTS) abilities. HOTS is an important skill in the 21st century because all problems existed around us must be resolved immediately. HOTS is one of the abilities to solve problems [10–13]. HOTS enhances students' problem-solving skills which is one of the vital skills of the 21st century. Problem-solving skill helps students to process certain information with logical reasoning and critical thinking in a method that can be used to solve the problem effectively and efficiently [10,14–17].

Materials related to plant physiology are available both at the school level and at university level. The implementation of plant physiology learning is usually found in several study programs such as Science Education and Biology Education. The concept of plant physiology is important to convey because it can be implemented in everyday life. The plant physiology concept at the university level is more complicated than at the school level, especially regarding growth regulators/plants hormones (*Zat pengatur tumbuh* or ZPT). Numerous concepts contained in the teaching materials need to be made into supplements [8,18]. A supplementary book is a book used to complement the main book [19]. The supplementary book is characterized by not being integrated directly to the learning objects, but it aims at strengthening concepts in the learning outcomes to be achieved [18,20–22]. Therefore, supplement books can provide information that follows the dynamics of knowledge development. The supplement books developed must be based on the latest research results.

Students as subjects who will use these teaching materials require a variety of knowledge from relevant studies. This is because students are directed to conduct a research for their study completion. Development of supporting teaching materials is a must to facilitate students in understanding various concepts that have been deemed difficult to understand [23–26]. One of the developed supporting teaching materials could be an E-Supplement Book Based on Plant Physiology Research

(ESPPRe). This media is an innovation in Biology Education, especially related to plant physiology. An analysis on student knowledge, especially in the realm of Higher Order Thinking Skills (HOTS) must be carried out prior to the development. Therefore, the purpose of this study was to measure students' HOTS related to concept of plant physiology as a basis for developing ESPPRe.

## 2. Methods

The research method used was a descriptive method with survey as a data collection technique. It was conducted in June 2020. The sample used was 72 Biology Education students who were taking plant physiology course. This research instrument was developed with 3 aspects, namely: analyze, evaluate, and create [27]. The HOTS instrument grid can be seen in Table 1. The instruments were given to respondents online via a Google form. After the HOTS score was obtained, the next step was analyzed the data and categorization. The categorization was according to Table 2, which was adapted from Ichsan et al [11]. This score category is intended to facilitate the determination of the student's HOTS score category. Student scores would be a basis for the development of ESPPRe media.

**Table 1.** Indicators of instrument

Aspect	Indicators	Item
C4 (Analyze)	Students can analyze factors causing stunted growth and plant development related to ZPT	1,2,3,4,5
C5 (Evaluate)	Students can criticize the role of internal and external factors in growth and development	6,7,8
C6 (Invent)	Students can create simple research designs and concept maps about plant growth and development	9,10

**Table 2.** Categories of students' HOTS scores

Category	Interval Score
Very High	$X > 81,28$
High	$70,64 < X \leq 81,28$
Moderate	$49,36 < X \leq 70,64$
Low	$38,72 < X \leq 49,36$
Very low	$X \leq 38,72$

Source: Category and interval score adapted from Ichsan et al [11]

## 3. Result and Discussion

The results of this study indicated that the average HOTS score of students in overall was still in a low category. This implied that HOTS-based plant physiology learning still required an improvement. Item with the lowest score was found in item 6 regarding the role of

gibberellins hormone. The HOTS score of each item is presented in Table 3.

The HOTS score for each indicator indicated that the lowest HOTS score was in the C5 aspect (evaluating). This signified that the students had not been able to maximize their ability to criticize various events related to plant physiology. They also had not been able to relate the theories acquired to facts in everyday life. The HOTS scores of students based on each indicator can be seen in Table 4.

The results of this study indicated that the students' HOTS scores in learning Biology, especially related to plant physiology, required an enhancement. The improvement needed was in all aspects, especially in the ability to evaluate and think critically. These abilities are critical because students need to criticize various problems related to biology. The critical thinking ability is a necessity in the 21st century. Critical thinking skills develop students with multiple skills such as conceptualizing skill, logical reasoning, application skill, analytical thinking, decision-making skill, and synthesizing skills [28,29]. Therefore, students who have

critical thinking skills will find it easy to adapt to various challenges of the 21st century to support sustainable development [13,30–34].

The ability to think critically in the context of plant physiology serves as a student's ability to examine the process of plant growth and development through growth regulators (ZPT). This process is important, as it is a complex process that includes several processes and the production of various metabolic products that can be used for several purposes. Various plants and their containing substances have some benefits that can be utilized by the community. Biological learning should be contextual and connected to the student environment so that students can understand material meaningfully [35]. The students' ability to think critically will encourage them to carry out various studies to find and develop a range of related products. Students can innovate to develop diverse products that have properties from different plant substances. The ability to develop these various innovations is important in being able to foster creative thinking skills in the 21st century [36–38].

**Table 3.** Student HOTS scores based on each item

No	Item	All	Male	Female
1	There is a control mechanism during the growth and development of plants from the genes to the individual level. Describe the linkages between gene-level control and biochemical level.	4.29	4.50	4.27
2	Research on barley seed germination indicates that there are more than one types of ZPT. Name the types of ZPT and describe the linkage of the working mechanism between the ZPT in the germination process.	3.90	3.75	3.92
3	In an experiment, plants that were positioned horizontally and upside down would turn upwards in a few days. Analyze this mechanism.	4.17	4.50	4.13
4	Two stalks of chrysanthemum, one of which was treated with ethylene. Analyze the differences in the results of the two.	3.88	3.75	3.89
5	Analyze what happens during the ripening process of a fruit. Describe what changes have occurred in the texture, color, and taste of the fruit and explain how this mechanism occurs.	3.79	3.75	3.80
6	Plants that will be applied with GA will bear fruit faster. Based on the basic concepts that you have obtained, describe your opinion on this.	3.63	3.88	3.59
7	Make a brief description of how abscisic acid plays a role in the adaptation mechanism of plants to drought.	3.86	4.00	3.84
8	When onions and potatoes are stored in a refrigerator for a few days, they will sprout. Explain your opinion about this phenomenon.	4.08	4.38	4.05
9	Create a simple research design to prove the existence of growth and development in plants. Write down the tools, materials, and methods of work from preparation until you get the data for analysis.	4.43	4.00	4.48
10	Create a concept map about growth and development in plants according to what you have learned.	4.78	4.88	4.77
Average Score (interval 0-100)		40.81	41.39	40.74
Category		Low	Low	Low

**Table 4.** Student HOTS scores based on each indicator

Aspect	Indicators	All	Male	Female
C4 (Analyze)	Students can analyze factors causing stunted growth and plant development related to ZPT	4.01	4.05	4.00
C5 (Evaluate)	Students can criticize the role of internal and external factors in growth and development	3.86	4.08	3.83
C6 (Invent)	Students can create simple research designs and concept maps about plant growth and development	4.60	4.44	4.63

Problem arises from the low HOTS needs to be overcome by developing book products. This is proven by several previous research results that show an increase in HOTS with book development [8,18]. In this case, book that can be developed is the ESPPRe supplement book. The book is an innovation in the form of supplements to support the development of student HOTS. The book is acquired from various research results. Students must be able to carry out various studies related to plant physiology. ESPPRe is an innovation in Biology Education as it already contains various components related to plant physiology research. The ESPPRe product is expected to provide supplementary knowledge to students regarding the latest findings in plant physiology.

The main aspect to be considered in developing the ESPPRe is content of the material to be presented. The material raised must have novel content so that students possess the latest information. The ESPPRe book should implement an activity instruction related to the development of students' HOTS abilities. For example, instructions for students to analyze and make a conclusion from the various research results. Further, students are also asked to criticize various problems related to the latest findings that have been presented in the ESPPRe book. These new ideas can be created by students to bring out novelty and can contribute to the progress of science [31,39,40].

The development of teaching materials such as ESPPRe is a necessity in the 21st-century Biology Education. The reason is that many students have not fulfilled all the skills needed in the 21st century such as the ability to criticize problems, think creatively, collaborate skills, and also communication skills [10,41–44]. Supplement books in biology tend to increase students' cognitive learning outcomes in terms of significance before and after the learning process [45]. Supplementary teaching materials prepared based on environmental potential can offer contextual insights and real-life experiences for students [2,46]. Contextual learning connects learning material to everyday life that can amplify enthusiasm and encourage students to apply knowledge [47]. This ability can be improved if students use teaching materials that have content to enhance these abilities. HOTS is an ability needed to foster student participation in criticizing problems and training students in creative thinking. The existence of ESPPRe is expected to encourage students to increase their HOTS.

## 4. Conclusions

Based on the research results, it can be found that the students' HOTS score was still in a low category so it needs to be improved. This low score is due to the low ability of students to criticize various problems related to plant physiology. It is necessary to develop teaching

material in the form of an ESPPRe supplement book for students. This book is expected to be an educational innovation in the 21st century due to its potential to increase HOTS. This book is recommended to be developed in the next research. Finally, students are expected to be able to create new ideas in solving these various problems.

## Acknowledgements

Thank you to the Faculty of Mathematics and Natural Sciences, Universitas Negeri Jakarta for the research funding in 2020 through the Faculty Competitive Research scheme.

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