Development of plant anatomy teaching material based on palynological studies of pollen impacted by the haze of *Hibiscus rosa-sinensis*

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**Abstract.** The research about palynological study of pollen impacted by the haze of *Hibiscus rosa-sinensis* from Riau Province and its development as a teaching material for plant anatomy has been conducted in Biology Laboratory of Islamic University of Riau. The objective of this research is to find out of the pollen morphology of *H. rosa-sinensis* and the result of this study developed for teaching materials for plant anatomy subject. The method is descriptive. The analysis data used descriptive qualitative. The result showed that pollen has several characteristics which can be observed which is impacted by the haze. Pollen was observed is single pollen type, spheroidal sarcoid, polyphenoporate aperture type and exterior ornament. From result of research can be concluded that there is difference of pollen analysis between plant observed. Implication of research results in learning in the form of teaching materials for Plant Anatomy subject. Based on the validation results, it is known that the teaching materials that have been prepared can be used in the learning with percentage level achievement of 90.91% for teaching materials. The subject matter of Plant Anatomy which has been prepared based on the research result can be used in the learning process.

1. Introduction

Education is indispensable to facing the global challenges of today's world. Through education, available natural resources can be utilized optimally for human well-being. Comprehensive education has a very important role in the development of science and technology. Therefore, education needs to get serious attention from various parties, especially those who directly related to the implementation of education. Students are required to have extensive knowledge, skills, managerial skills, and other skills, so students need to have a 21st century skills consisting of life and career skills, learning and innovation skills, information, media, and technology skills is needed [1, 2]

A good learning system can provide learning experiences to students to unlock their potential in internalising knowledge, skills, and behavior and previous learning experiences. Therefore, it is important for educators who teach in universities to make study materials and lessons that match the knowledge and ability to be mastered. Study materials and lessons can be made in the form of textbooks, modules, handouts and so forth.

Plant Anatomy is one of the compulsory courses contained in the Biology Education Study Program. The study material for this course is still limited and has not been adapted to the knowledge and ability to be mastered by the students. At the time of attending college, students find it difficult to follow or capture the meaning of the essence of learning materials. In addition, books and references
related to the material in the course of Plant Anatomy, especially the study of pollen is still limited and are common to the examples described in general types that are located outside of Riau or even outside Indonesia. In practicum activity on plant flower pollen observation material in the laboratory, students experience constraints in determining the object of the observed sample and relate it to the phenomenon that it faces daily. In addition, until now there has been no research on the analysis of palynology of plants affected by haze in Riau Province and its development for teaching materials in universities. Therefore, it is important to choose the method used in the most appropriate learning process that is with the development of teaching materials that are representative.

One of the learning methods that can be applied is contextual learning based (contextual learning).

With the analysis of plant palynology affected by smoke haze in Riau Province applied, it is expected to assist students in understanding the lecture material as well as connecting it with their experiences in daily life. The study of palynology analyzed consisted of: type of pollen, pollen morphology, and pollen viability related to the environment in which it was grown. Teaching materials is an important part of education implementation. Through teaching materials, educators will be easier in implementing learning and students will be more helpful in learning. One of the benefits of teaching materials is to enrich the information that students need in learning and make it easier for students to learn a certain competence.

2. Methods

This study includes two phases, the first phase consists of research is observational research (exploration) plant pollen cells affected by haze in Riau Islamic University campus area. This is done through the study of palynology by direct observation of fresh preparations of pollen under a microscope. The second phase is the development of research-based teaching materials contextual assisted learning lab handouts on the material observations pollen cell and its application in the course Anatomy Plant in Biology Education Studies Program. This research was conducted by the lecturer of Anatomy Plant lecturer at Biology Education Program FKIP Universitas Islam Riau.

The parameters in this research are: pollen analysis and feasibility of handout to be applied in the learning process and the attractiveness of handouts that have been developed. The instrument in this study is a questionnaire containing questions related to the material used in the course of Plant Anatomy. In the questionnaire there are five choices ranges of answers given by students [3].

The development model in this research is procedural model. Procedural model is a model that is descriptive, which outlines the steps that must be followed to produce a product (modified based on [4]. The product developed is a handout on the Plant Anatomy Course. In line with the development objectives set forth in the introduction, this model of development is a procedural model. Procedural model is a descriptive model, which outlines the steps that must be followed to produce a product. Research development in this research was developed by using modified four-D-models, ie through define, design, and develop stage without dissemination stages. This method was modified from [5].

The observational data of palynology study were analyzed descriptively, and interpreted from photos and graphs. In research development to analyze student answer in handout at course of Plant Anatomy which is developed by technique percentage [4] with formula as follows:

\[
PRM = \frac{n}{N} \times 100\% \quad (1)
\]

Description: 
- \(n\) = number of samples
- \(N\) = total number of samples
- PRM = percentage of student respond

From the percentages obtained are grouped according to the criteria in Table 1 below:
Table 1. Revision Handout Decision Making

| Level Achievement | Qualification     | Description       |
|-------------------|-------------------|-------------------|
| 81-100            | Very Eligible     | No need to be revised |
| 61-80             | Eligible          | No need to be revised |
| 41-60             | Simply            | Revised           |
| 21-40             | Improperly        | Revised           |
| 0-20              | Very Poorly       | Revised           |

The development research has produced a hand out on sub-material observation of plant flower pollen cells. This research was a research and development design (R & D). The developed hand out was validated first by the learning and teaching material expert. The hand out was tested limited to the Plant Anatomy to obtain the student's response. Research sample was 20 students who took the course of Anatomy of Plant that represent the target population [6]. The development of the first stage of the research was developed by a modified four-D (4D) method. Due to the limitation of time and resources, development research is limited only to the development stage.

3. Results and Discussion

Based on the research that has been done got the following results:

3.1. Palinology Analysis

Based on the Palynology analysis of Hibiscus flowers (Hisbiscus rosa-sinensis) has been done, observed pollen cells in the form of a single pollen (Figure 1), with the type of spheroidal oblate, with aperture polypontoporat. This is in accordance with the results of research that has been done by [7], found that the Hibiscus rosa-sinensis have oblate spheroidal pollen types, namely the type aperture with ornamentation exine polypontoporat echinate which has a section called echini, which are part of the ridge on the pollen wall ornament length / thickness more than 1 lm. This is also consistent with the results of research conducted by [8], which states that the pollen in flowers of Hibiscus (H. rosa-sinensis) has a pollen grain size of 138-155 μm, with the type of pollen grains permagna carvings, have echinate exine ornamentation type, with a length of 7.32 to 13.0 μm echinate distance 22 lm, and have the pollen oblate spheroidal shape.

![Figure 1. Anatomy of Pollen of H. rosa-sinensis](image)

In observation of plant pollen cells located in the campus area of Islamic University of Riau that has been done, it was found that the viability of observed pollen cells is strongly influenced by environmental conditions around where the plant grows (Figure 2). Whereas at the time of the flower research sampling, the environmental conditions are exposed by the haze, so that it is observed under a microscope of some non-viable pollen cells.
This shows that the viability of pollen grains is strongly influenced by the haze occurring in Riau Province at the time of the research. Whereas, the viability of plant pollen affected is lower than the viability of plant pollen that is not affected by the haze. Non-viable pollen seems hight percentages of pollen patterns that affected by the haze, whereas exhibit features, its consist of cell walls and empty spaces within the pollen cells. The haze has affected pollen cells by causing the total destruction of non-viable pollen cell walls. This case also impacted the viability of pollen. There are many factors can influence that, such as: temperature, water content, and the maturity level of pollen cells. This is in accordance with the results of research showing that factors that affect a low viability of pollen are the level of maturity of pollen cells [9]. As well as environmental factors such as temperature and water content [10], the moisture content in cells or tissues greatly affects the dehydration process. At room temperature, pollen is faster to lose its viability due to faster and more physiological activity the energy released so that pollen will be more quickly damaged and can only survive in the short term. These factors are also found in [11], that the viability of dragon fruit pollen is highly influenced by environmental factors. This is related to the factor of transpiration velocity of pollen cells [12].

![Figure 2. Anatomy of Viable and Non-viable Pollen Grains of *H. rosa-sinensis*](image)

(a) Viable Pollen grains, (b) Non-viable Pollen grains

### 3.2. Development of Teaching Materials for Course of Plant Anatomy

Description of the implementation of research development activities described as follows:

#### 3.2.1. Define Stage (Initial Analysis)

Based on the results of define stage analysis formulated that is necessary to be pursued in plant anatomy learning process. The course required material of specially printed material which is can be used by students as independent learning source. It needs teaching materials that describe concepts with trace and focus that can help students in understanding the material. It takes teaching material that outlines concepts in a concise way so that it is easy to remember. It takes teaching materials that integrate the lecture materials with facts in everyday life, in this case the plants affected by haze, and required teaching materials equipped with photo documentation of observations under the microscope to facilitate students to determine the object of observation in laboratory activities in the Biology Laboratory. In addition, also needed teaching materials that can be used in helping students understand the terms in the discussion of the material in the course of Plant Anatomy.

#### 3.2.2. Design Stage (Design)

From result of define stage formed the instructional design. Hand out material adapted to the syllabus and learning objectives course of Plant Anatomy. The preparation of hand out attributes and typing of handout material by using Program CorelDRAW Graphics Suite X4, with A4 paper size, Times New Roman writing size 12, and layout with 1 column. Through the design phase of the product produced in the form of a hand out. All contents of the handout are printed in color to clarify the images and other components loaded in the handout.
3.2.3. **Develop Stage (Development).** The quality of handouts that have been developed based on the assessment of two experts fall into either category. Which is can be seen in Table 2:

| Indicator              | Percentage of validity (%) | Qualification |
|------------------------|-----------------------------|---------------|
| Format of Handout      | 74.29                       | Good          |
| Grammar                | 93.75                       | Very Good     |
| Design                 | 80                          | Good          |
| Handout Style          | 75                          | Good          |
| The Uses               | 80                          | Good          |
| Average                | 76.8                        | Good          |

Based on Table 2 it can be seen that the results from teaching materials assessment expert ranged from 74.29% to 93.75%. This result showed that the handout included into the good category to very good category with an average percentage is 76.8%. This indicates that the handout is in good and excellent qualification. The recapitulation of validation results by teaching material experts can be seen in Table 3:

| Indicator                      | Percentage of validity (%) | Qualification |
|--------------------------------|-----------------------------|---------------|
| Quality of Development Teaching Material | 93.33                      | Very Good     |
| Quality of Material            | 90                          | Very Good     |
| Grammar                        | 86.67                       | Good          |
| Average                        | 90                          | Very Good     |

Table 3 shows that the assessment results from teaching material expert ranged from 86.67% to 93.33% included in the excellent category with an average percentage of 90%. This indicates that the teaching materials in the form of handouts are included into the very well category and compatible with the material studied in the Plant Anatomy course. Recapitulation of validation results by the experts shown in Table 4:

| Validator               | Percentage of validity (%) | Qualification |
|-------------------------|-----------------------------|---------------|
| Material Experts        | 90                          | Very Good     |
| Media Experts           | 76.8                        | Good          |
| Average                 | 83.4                        | Very Good     |

Table 4, validation results from media experts and material experts reached the percentage of 83.4% (very good category). Thus the content of Plant anatomy handout based on contextual design that has been evaluated by the expert team as a whole is included into the category very well. However, revisions are still made based on responses and suggestions from experts either submitted directly or provided in writing in the response and suggestion columns. Some criticisms and suggestions are the scope of handouts should be added, each activity learning or laboratory learning should be translated, practices and tasks for enrichment learning should be added, and layout design must be more interesting.

The revised handout then printed and tested in the plant anatomy course. The percentage of feasibility of handout of contextual interest-based floral anatomy learning subject by each can be seen in Table 5.
Based on the results described in Table 5, it is known that the design is very suitable to be used in the Plant Anatomy course (84.35%) (very good category). This is in accordance with researchers [13,14], who stated that the feasibility assessment is very important to ensure that proper teaching materials is used in the learning process.

The development research design was implemented through several stages which are defining stage, designing stage, developing stage, and implementation stage. One of the steps included in the core step of development of teaching materials is the validation test. This is in accordance with [3,15], which stated that the validation test is done in an effort to produce a good teaching materials and relevant with theoretical foundation.

Through validation and feasibility tests of teaching materials, it is concluded that hand out of plant anatomy based on contextual development is considered feasible to be used by students in the lectures as learning resources for students to construct knowledge independently. The presentation of materials that fit to demand of students expected improve students' knowledge and understanding. The hand out is written materials containing important concepts of a learning material [14, 16]. Teaching with this hand out is an effort to organize individual teaching that enables students to independently construct a concept from one or more unit of learning material in accordance with the contents. Knowledge is not a set of concepts, materials and rules that are ready to be taken and remembered, but humans can construct knowledge by giving meaning through real experience [17,18]. This is in accordance with previous research which found that the use of contextual-based handouts enhances students' understanding of lecturing materials, one of them is on Embryology [19]. In addition, the development of booklets can be used as a source of learning on the morphology and anatomy of plants [20].

4. Conclusion

Based on the research result that has been done, it can be concluded that analysis of plant pollen grains studied showed that in general the type of plant observed tetrahedral tetrad with aperture type is syncolporate. In hibiscus flowers pollen cells are single pole, spheroidal type of spleen, aperture type is polypantoporat, and ornamentation echinate. There are differences in anatomy of pollen between the observed plants. Implication of research results in learning in the form of learning resources in the form of handouts based on contextual learning on the subject of Plant Anatomy. Based on the validation results, it is known that the teaching materials based on handouts can be used in the learning. Alternative design of learning resources in the form of handout based on contextual learning on the subject of Plant Anatomy that has been prepared based on the results of research can be used in the learning process (very unevaluable need not be revised).

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