Development of a molecular plant taxonomy textbook

Imas CINTAMULYA* and Lilik MAWARTININGSIH

Department of Biology Education, PGRI University of Ronggolawe, Tuban, East Java, INDONESIA

***Corresponding Author's E-mail: cintamulya66@gmail.com**

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Contents

Abstract

The plant taxonomy textbooks that are generally used in colleges need to be complemented with a DNA-based molecular review. In general, plant taxonomy textbooks devote more space to morphology than to molecular-level characteristics.

The research reported here used the results of DNA-based research to develop a molecular plant taxonomy textbook. The purpose of this research was to develop a suitable plant taxonomy textbook that was valid, practical, and effective. The textbook is useful to provide students insight into plant taxonomy from a molecular perspective. To achieve that goal we used the Plomp development method, which consists of five stages: (1) the initial assessment phase, (2) the design phase, (3) the realization /construction phase, (4) the test, evaluation and revision phase, and (5) the implementation phase. The quality of the plant taxonomy textbook based on a molecular approach was assessed using following criteria: validity, practicability, and effectiveness. Further testing of the quality of the textbook and supporting devices was conducted with biology students taking a Higher Plant Botany course. Analyses of these data showed that the textbook met the validity, practicality, and effectiveness standards.

Keywords: Molecular approaches, Morphological approach, Plant taxonomy, Quality book, Textbook.

Introduction

Taxonomy is always related to the study of biodiversity. According to Adisoemarto (2008), the role of taxonomy is to reveal biodiversity. Therefore, this scientific discipline promotes the preservation of biodiversity. Along with the increase in the population of Indonesia, many human activities threaten biodiversity. Every year, millions of hectares of tropical rainforest are threatened with extinction, removing their ecosystem functions and converting them into housing, plantations, and mining. Those activities result in a large decrease in biodiversity, and even the extinction of many genes. This is why information on biodiversity at the species and genetic level is needed to conserve and manage biodiversity. In light of this, taxonomy must promote protecting and utilizing the existing biodiversity optimally, so that it can be useful for present generations and the future (Saptasari, 2012). This objective can most effectively be achieved through a college education, especially in study programs of biology education and biology by providing students with knowledge of plant taxonomy and instilling a sense of the importance of preserving biodiversity as well as their own responsibility for promoting it. A meaningful taxonomic education is very important to achieve this goal. As suggested by Adisoemarto (2008), it can be done by following some guidelines, one of which is following the development of the knowledge needed for taxonomic performance adjustments and then empowering it.

Learning about plant taxonomy is facilitated by the availability of a high-quality textbook. In fact, according to the National Education Ministry's regulation of Indonesia No. 11/2005 Article 2, a textbook is necessary to achieve national educational objectives and is mandatory. A textbook is important in teaching and learning activities because it can serve to improve the competence of students. In addition, a textbook facilitates independent learning. Therefore, procuring a textbook accompanied by guidance in how to use it is very important. However, plant taxonomy textbooks that discuss both morphological and molecular subjects are still rare. Thus, the knowledge of plant taxonomy presented to students through their textbooks is usually incomplete (Wisanti et al., 2012). Therefore, to describe plant taxonomy as fundamental means that it is part of the foundation of scientific disciplines that study plants. Plant taxonomy should be able to follow the current developments of science and technology, which are primarily associated with the development of molecular biology. Rifai (2003) states that, in line with current developments and needs, taxonomy of selected biodiversity should emphasize an understanding based on molecular biology approaches, thus preparing students to enter the era of biotechnology. As technology advances in plant analysis of, it tends to use a genetic approach more frequently rather than a changing descriptive analysis. Educators in the fields of biology and biology education should provide knowledge of molecular biology to students through the study of relevant topics. One of these is plant taxonomy. Graham (2000) states that taxonomists use molecular systematics to support morphological methods that are used to identify species in more rapid and precise way. This is a challenge that must be faced by educators in the biology and biology education fields. Educators must be prepared to explain the molecular processes that occur in a cell. Such knowledge can be used to improve human welfare in the future. If an understanding of molecular biology becomes widespread, then efforts at maintaining biodiversity and environmental preservation will achieve much greater success.

According to Rifai (2012), molecular biology should become a full course for biology students. Molecular studies should be obligatory for the students of biology education. Students are not complacent to continue studying the biological sciences that have begun to have developmental lags. In addition, Rifai (2008) said that textbooks should be based on the progress of science. Advances in science courses can be obtained through the study of current research results, especially studies of molecular biology in the field of plant taxonomy. There have been many uses of molecular research in plant taxonomy. However, the progress of molecular research in the field of plant taxonomy is still fragmented into scientific articles. Therefore, it is necessary to develop plant taxonomy textbooks based on molecular research. Molecular-based research uses molecular data and information to complete plant taxonomy material that still has weaknesses because it is still dominated by

conventional morphological techniques. The plant taxonomy textbook based on molecular research can be used in the taxonomy learning process in accordance with the modern techniques.

Based on the description above, the problem at hand is how to develop a suitable (valid, practical, and effective) molecular plant taxonomy textbook based on current research. The objectives of this study include:

1) developing a suitable (valid, practical, and effective) plant taxonomy textbook based on molecular research, and
2) developing similarly suitable supporting devices. The supporting materials include practical instructions and an evaluation sheet.

Materials and Methods

Type and Design of Research

This research is a development research (in the field of education) with research design according to Plomp (1997), consists of five stages, namely: 1) the initial assessment; 2) design; 3) realization/construction; 4) testing, evaluation, and revision; and 5) implementation. The choice of the Plomp model refers to the opinion of Van den Akker and Plomp (1993) that education design research is based on two objectives, namely the development of product prototypes and the formulation of methodological suggestions for the design and evaluation of prototypes of these products. One model of education design research based on these two objectives is the Plomp model. T the Plomp model is used as an alternative method in educational research generally used widely in the development of learning devices. Therefore, this Plomp model is relevant for the development of molecular plant taxonomy textbooks. In addition, the advantages of the Plomp model are the methodical testing and evaluation of a prototype until a valid product is obtained through several revisions of the design.

The method we used is research and development or R & D according to Gall et al. (2003) and Sukmadinata (2005), whose steps include:

1. A preliminary study whose activities include research and data collection
2. The development of the prototype and preparation draft
3. Testing and evaluation of products which include: a) testing the product draft; b) revising or improving the product; c) testing whether products have been perfected; d) enhancing product improvement; e) testing whether a product has been improved; f) field testing a product that has been improved; and g) disseminating, implementing and institutionalizing the product.

This study was conducted in students at biology education program in Ronggolawe University, Tuban, East Java, Indonesia at Higher Plant Botany class.

Implementation of the Study

The research was conducted over a two-year period. The first year involved researching the material and development of the textbook. There are three components that needed to be developed:

1) the plant taxonomy textbook itself;
2) supporting devices to accompany the plant taxonomy textbook, including practical instructions and evaluations; and
3) the instruments that were to be used to assess the quality of the textbook.

The implementation of the second year of research was a continuation of the first year of study, which was a period of testing their validity, practicality, and effectiveness and developing a final prototype.

Data Analysis

The data analyzed in this study include data regarding the validity, practicality, and effectiveness of the textbook. The analysis of the validity and quality of the school textbook was carried out by five expert validators. To determine the practicality of the molecular plant taxonomy textbook based, we used the syntax cooperative learning model while incorporating the textbook and its supporting materials.

Thus, observation of the practical utility of the textbook aimed at accomplishing a cooperative learning process using the plant taxonomy textbook and its supporting materials (practical instructions and evaluation). The effectiveness of the textbook would be supported by the results of analysis of the four components of effectiveness, namely:

1) students' learning outcomes;
2) students' and lecturer's performance;
3) students' responses to the learning process through the textbook, and
4) the ability of the lecturer to manage the learning process.

Results and Discussion

The results of analysis of the validity of the textbook and supporting materials (practical instructions and evaluation) are in Table 1. The practicality of the textbook

and supporting materials can be seen from the learning process in this case by using cooperative learning from the molecular plant taxonomy textbook. The results of the data analysis of the practicality of the textbook and supporting materials can be seen in Table 2. The effectiveness of the textbook is supported by the results of the four components, namely: 1) student learning outcomes; 2) student activity, 3) the student response to the textbook-based learning process; and 4) student learning ability. These results can be seen in Figure 1. The student and lecture activities, response, and learning management are presented in Table 3-6.

Validity of the Textbook and Supporting Materials

Testing the validity of the molecular plant taxonomy textbook and supporting devices (evaluation and practical instructions) involves Nieveen's criteria (1999), which include validity, practicability, and effectiveness. Table 1 shows that our new molecular plant taxonomy textbook fulfilled the validity criteria. Validity is an accurate interpretation of the measurement or evaluation of results (Gronlund and Linn, 1990). This means that the molecular plant taxonomy textbook already has an accurate interpretation based on the results of the validators' assessment. Aspects with high validity include the preface, the chapter description, the practicality of the contents, abstract and other features. The preface in this textbook was evaluated as explaining the need for the textbook well. This is in line with the opinion of Kunz (2016), who said that the preface has an important role as a place to explain the need a textbook.

Table 1. The results of the validity of plant taxonomy textbook based on molecular approach and supporting devices (practical instructions and evaluation).

Aspects	Score Total (Five Validator)	Average	Category
Title	16	3.2	Valid
Preface	17.3	3.5	Very Valid
Chapter Overview	17.2	3.4	Very Valid
The Feasibility of Contents	16.9	3.4	Very Valid
The Presentation of Contents	15.8	3.2	Valid
Rules of Language and Illustrations	16.0	3.2	Valid
Summary	17.6	3.5	Very Valid
Exercise	16.3	3.3	Valid
Reference	16.0	3.2	Valid
Other Completeness	17.8	3.6	Very Valid
Practical Instructions	16.7	3.3	Valid
TOTAL	**183.6**	**3.338**	**Valid**

Information: Category of Validity: $3.4 \leq M \leq 4.0$ (Very Valid); $2.5 \leq M \leq 3.3$ (Valid); $1.7 \leq M \leq 2.4$ (Quite Valid); $1.0 \leq M \leq 1.6$ (Less Valid)

Results for the chapter overviews and the feasibility of contents also showed high validity. This means that the chapter overviews met expectations regarding the breadth and depth of the material covered and suitability for the competencies to be achieved. It can be seen from the textbook's table of contents that the materials presented are up to date, especially in terms of recent developments in molecular biology. This is in line with the opinion of Legowo (2011), who explains that the scope of the material covered in a textbook, and depth of coverage, must be precisely calibrated in accordance with the competencies that will be achieved. In addition, Legowo (2011) also explains that the material presented in the textbook must follow the latest scientific developments and the material presented must be sophisticated. Harden et al. (1984) emphasize that the materials and stages must be clear, logical, and systematic in assisting students to gain a better understanding of the course material and ultimately achieve competency in its entirety. Thus, the plant taxonomy textbook has met the validity criterion, which includes the sophisticated and innovative learning.

The summary is a component in the plant taxonomy textbook that showed a high validity. The summary was either from a proportional description of material in each chapter in the molecular plant taxonomy textbook or a summary of the important things from the material described in the textbook. Summaries facilitate understanding by outlining the material in a chapter (Ruswanto, 2015). Summaries of the molecular plant taxonomy textbook have high validity, which means that a summary contained proportionately important things about the material described in each textbook chapter. This facilitates the students' understanding of the outline of the materials of each chapter in the textbook.

Another supplementary component is the glossary. The glossary is a list of words or important concepts from the material of the molecular plant taxonomy textbook- with their definitions. Ruswanto (2015) states that the glossary functions to facilitate the search for the meanings of unfamiliar vocabulary words. Thus, the glossary in this textbook will provide convenience to the student reader for understanding the meanings of words that they may consider difficult.

Validation testing is important to see the compatibility of product development with needs. One purpose of the validation of molecular plant taxonomy textbooks is to see the suitability of the content of the material or substance of the textbooks and evaluate it with the expected learning outcomes (Afrahamiryono and Ariani, 2017). Therefore, the validity of molecular plant taxonomy and their supporting devices determines their feasibility of use in the learning process.

Practicability of Textbook and Supporting Devices

The practicality of the textbook and auxiliary materials (practical instructions and evaluations) is based on the implementation of the learning process, in this case, cooperative learning based on the textbook. Components observed for implementation of the cooperative learning process using the molecular plant taxonomy textbook include those mentioned by Joyce et al. (1992). These consist of a syntax that includes several aspects: 1) the level of implementation of all stages of learning; 2) coverage of the important aspects of learning in Advanced Plant Botany, 3) and implementation of a sequence of learning activities by using the molecular plant taxonomy textbook and supporting material. Social Systems, covering: 1) the level of implementation to the situation (atmosphere) expected (forming groups, discussion, questions, debate, proposals, mutual respect during the process); 2) the level of implementation of learning interactions (student to student, and student to instructor); 3) the level of implementation of lecturer behavior embodies the principles and concepts of learning in Plant Taxonomy. Reaction Principles and Management includes the following aspects: 1) the level of implementation of lecturers in accommodating and providing opportunities for students to ask questions, submit opinions and give feedback; 2) the level of adherence to lecturers to providing assistance, and guidance; 3) the level of implementation of the behavior of lecturers into motivation of learning the molecular plant taxonomy-based approach; 4) the level of implementation of lecturers involving students actively in learning and practical activities; 5) the level of implementation by the lecturers in facilitating learning of students.

Table 2 shows the average score for the implementation of the learning process using the molecular plant taxonomy textbook, which ranged from 3.9– 4.4. This shows that learning in the course of Advanced Plant Botany by using molecular plant taxonomy textbooks-supporting devices has been implemented as a whole. Referring to the criteria Nieveen (1999) used, which include the validity, practicability, and effectiveness of the molecular plant taxonomy textbook-based approach, it meets the criteria practicability. According to Akker (1999), practicality refers to the degree that the user (or other experts) considers the intervention can be used, preferably under normal conditions. While Nieveen (1999) argued to measure the practicality based upon whether the teacher (and other experts) considered the material easy and usable by teachers and students.

Table 2. The results of the practicality of plant taxonomy textbook based on molecular approach and supporting devices (practical instructions and evaluation).

Meeting	SCORE			Category
	Observer 1	Observer 2	Average	

	Σ	$\overline{X}$	Σ	$\overline{X}$	Σ	$\overline{X}$	
The first meeting (March 22, 2016)	46	4.2	45	4.1	91	4.1	Entirely implemented
The second meeting (March 29, 2016)	45	4.1	40	3.6	85	3.9	Entirely implemented
The third meeting (April 5, 2016)	43	3.9	44	4.0	87	4.0	Entirely implemented
The fourth meeting (April 12, 2016)	50	4.6	42	3.8	92	4.2	Entirely implemented
The fifth meeting (April 19, 2016)	48	4.4	48	4.4	96	4.4	Entirely implemented
The sixth meeting (May 3, 2016)	42	3.8	44	4.0	86	3.9	Entirely implemented
The seventh meeting (May 10, 2016)	43	3.9	44	4.0	87	4.0	Entirely implemented
The eighth meeting (May 24, 2016)	46	4.2	42	3.8	88	4.0	Entirely implemented
The ninth meeting (May 31, 2016)	45	4.1	46	4.2	91	4.1	Entirely implemented
The tenth meeting (June 16, 2016)	43	3.9	44	4.0	87	4.0	Entirely implemented
The eleventh meeting (June 21, 2016)	50	4.6	42	3.8	92	4.2	Entirely implemented
Average	**501**	**4.2**	**4\81**	**4.0**	**982**	**4.1**	**Entirely implemented**

Information: Category Learning Implemented: $3.0 \leq M \leq 5.0$ (entirely implemented); $2.0 \leq M \leq 3.0$ (partially implemented); $1.0 \leq M \leq 2.0$ (not implemented)

According to Akker (1999) and Nieveen (1999), the practicality of developing molecular plant taxonomy textbooks is feasible for use in the learning process. Molecular plant taxonomy textbooks are books that can be used to achieve learning objectives such as important molecular knowledge related to plant taxonomy. Molecular studies help to reveal data that is still difficult to understand morphologically. According to Amin and Lestari (2015), molecular data can be used in conservation efforts. In addition, according to Rifai (2012), students need to be equipped with molecular concepts and techniques. Therefore, an important molecular approach is given to students in biology education department students through molecular plant taxonomy textbooks, so that students understand taxonomy and their molecular data for conservation purposes.

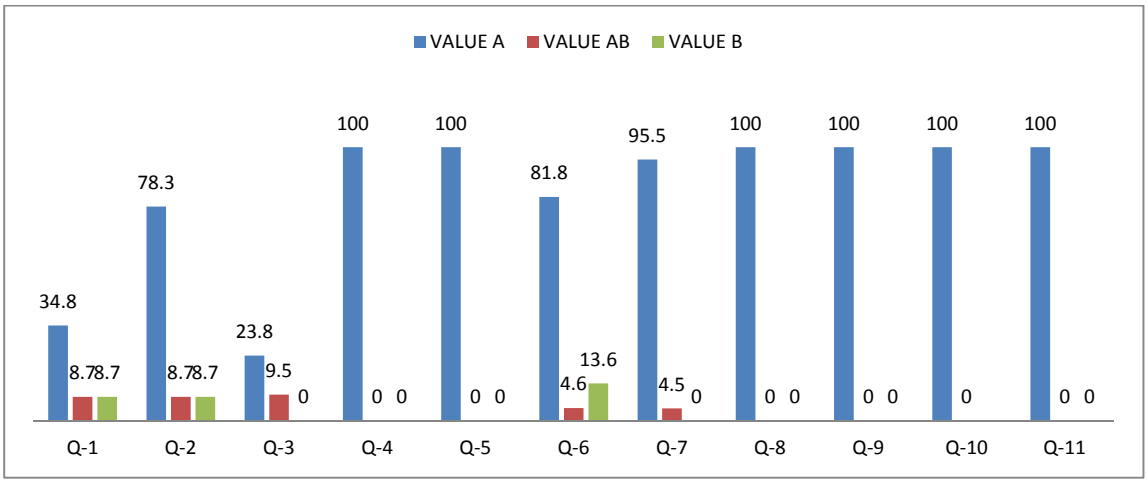
Effectiveness of the Textbook and Supporting Devices

The effectiveness of the textbook is supported by the data analysis of the results of the effectiveness of the four components, namely: 1) the results of student learning

outcomes; 2) student and lecturer activity; 3) the response of students to the learning process while using the textbook; and 4) the ability of lecturer to manage the learning process. The data analysis of all four components was as follows.

a) The results of student learning outcomes

As shown in Figure 1, at the first meeting, only about 52.2% of students received quiz scores close to 70%, or a minimum value of B. In the group of students who achieve mastery, the percentage of individuals with an A was higher than the percentage of students with grades AB and B. As for classical completeness, at the first meeting this was not achieved because there were many students who scored at or below 48.8%. At the first meeting, the average students who belong to the category of the high academic skill achieved individual completeness whereas classical completeness at the first meeting has not been reached. The students were still adapting to the learning process of Botany of Higher Plant configured in a cooperative learning model with presentation, discussion, and assignments as well as the use of molecular plant taxonomy textbooks.



Information: Q1-11: Quiz 1-11. If a student gets Quis Score 70 then the student achieves mastery individuals. If a minimum of 85% of the students achieved a score of at least 70, then the classical completeness has been reached.

Figure 1. Percentage of Student Learning Outcomes in Learning Process High Plant Botanical by Using Plant Taxonomy Textbook Based on Approach Molecular.

At the second meeting, the percentage of students who received quiz scores of 70% or a minimum grade of B increased compared to the first meeting, to about 43.5%. In this group of students, 78.3% achieved an A, whereas 17.4% had grades of AB or B. Thus, the classical completeness in the second meeting has been reached because the percentage of students who obtained a minimum grade of B was around 95.7%.

The percentage of students who scored below B was only 4.3%, a decrease 43.4% compared to the first meeting.

At the second meeting, the students who belonged to the category of high and medium academic performance had already achieved individual and classical completeness. An increase in terms of completeness of individual and classical compared to the first meeting assumes that the students have started to adapt to the models, methods, and molecular plant taxonomy textbook-based approach. During the second meeting, the material covered was of the history of plant taxonomy and taxonomic structures, which primarily require memorization, and 95.7% of the students memorized the material well enough to get at least a B on the quiz.

At the third meeting, the percentage of students who received quiz scores of 70 or the equivalent with a minimum grade of B decreased 62.4% compared to the second meeting. In this group of students who achieved mastery, the number of individuals with an A grade decreased 54.5% compared to the second meeting, and students with AB consisted of about 9.5%, or an increase of 0.8% compared to the second meeting, and there were no students who got a B. Thus, the classical completeness was not achieved at the third meeting, because only about 33.3% of the students received a minimum grade of B, while the percentage of students who scored less than B was 66.7%.

At the fourth and fifth meetings, the percentage of students who received scores of 70 or the equivalent with a minimum grade of B increased by about 66.7% compared to the third meeting. In this group of students, the percentage of those who achieved an A rose 76.2% compared to the third meeting. At the fourth and fifth meeting, all students got an A, with a score ranging between 91–100 at the fourth meeting and a score between 89– 100 for the fifth meeting. The substantial increase in scores by the fourth and fifth meetings was assumed to mean that the students have adapted to the learning process of Higher Plant Botany configured in a cooperative learning model with the method of presentation, discussion, and assignments as well as the use of the molecular plant taxonomy textbooks. In addition, the material in Chapter IV was on the collection and preparation of specimens of plants, as well as a practicum on the identification of plants in nature, and it helped students to understand the material in this fourth meeting. Meanwhile, related to Chapter V, which was on the nomenclature of plants and phylocode as a new nomenclature system, the material about the nomenclature of plants had already been presented in previous coursework. For the new phylocode nomenclature system as students advanced, they assigned to study the original paper to practice analyzing the relevant similarities and differences between the traditional plant nomenclature system with the new phylocode nomenclature system. The achievement of classical completeness was 100% for the fourth and fifth meetings.

At the sixth meeting, the percentage of students who received an A grade on the quiz decreased by 18.2%, compared to the fifth meeting. This happened because there were some students who received grades of AB (about 4.6%) and B (around 13.6%). The existence of groups of students who receive grades AB and B were assumed for the material in Chapter VI, which discusses approaches used in plant taxonomy. As already mentioned, Chapter VI contained many important new concepts from a variety of approaches (morphology, anatomy, cytotaxonomy, palynology, embryology, ecology, paleobotany, chemistry, serology, and molecular biology) that must be understood by the students. However, overall for the six meetings, classical completeness has been achieved for 100% because all of the students got good grades.

At the seventh meeting, the percentage of students who received grades of A decreased by 4.5%, compared to the fifth meeting. This happened because there were some students (about 4.5%) who received grades of AB. The groups of students received grades of AB for the material in Chapter VII, which discusses the role in the molecular study of plant taxonomy. The material in Chapter VII was early in the discussion of molecular material in the plant taxonomy textbook so that there were students so that students' grades are still not optimal. However, at the seventh meeting, overall classical completeness has been achieved for 100% because all students got good grades.

At the eighth, ninth, tenth, and eleventh meetings, all students received grades of A; scores at the eighth meeting ranged from 88–100, scores at the ninth meeting ranged from 82–100, and scores of the tenth and eleventh meetings ranged from 85–100. This shows that at the eighth, ninth, tenth, and eleventh meetings, classical completeness has been reached. The students had adapted to the learning process of the course through the cooperative learning model based methods of presentation, discussion, and assignments. In this study, we also started to empower students with analysis capabilities in the study of molecular plant taxonomy.

b) Student and lecturer activities

To investigate the students' and lecturer's activities, observations conducted during the last the trials. The observations were performed by two observers, so that the data obtained was more valid. The analysis was performed at the ideal time spent on each aspect assessed. The analysis of students' and lecturer's activities was directed at determining the effectiveness of components both individually and together at each meeting. The effectiveness of each component was based on the ideal time criteria (shown in percentages), while the criteria for the effectiveness of all components is shown in Table 3.

Table 3. Student and lecturer activities during the learning process.

	Type Activities Student Activities	Range Effectiveness	The Average Index of Effectiveness	Information
1	Listening to the lecturer's/frend's explanation	45%-55%	53.3%	Effective
2	Reading texbooks	20%-30%	22.6%	Effective
3	Writing relevant to teaching and learning activities	0%-10%	5.8%	Effective
4	Discussion between students and lecturer	5%-15%	10.2%	Effective
5	Discussion among collage students	5%-15%	8.8%	Effective
6	Behavior that is not relevant to teaching and learning activities	0%-5%	0%	Effective
	Lecture Activities			
1	Explain / give information (problem)	35%-45%	36.7%	Effective
2	Viewing the student activities	15%-25%	21.8%	Effective
3	Motivating students	5%-15%	12.1%	Effective
4	Giving instructions / guide activities	25%-35%	27.7%	Effective
5	Behavior that is not relevant to teaching and learning activities	0%-5%	0%	Effective

At the first meeting, the student activities were effective, although they had not met the ideal time criteria. For the lecturer's activities, there was still an ineffective component, which was students' motivation. This was because, at the first meeting, it was necessary to provide motivation in order to implement the learning process as designed. At the first meeting, the students' activities were very effective because all the components demonstrated the effectiveness of the students' activities, while the activities of faculty were effective based upon the four components previously mentioned.

At the second meeting, students were still not effectively observing and listening to explanations by the lecturers and colleagues. At the second meeting, which involved discussion of the history of plant taxonomy and taxonomic structure, the content required much memorization. The other components were effective, although they had not fulfilled the ideal time criteria. All components of the lecturer's activities were effective. At the second meeting, the students' activities were effective for five components, whereas the activity of the faculty were very effective because criteria for all of the components were met.

At the third meeting, writing components relevant to teaching and learning were still not effective. The third meeting discussed the various plant classification systems. A characteristic of the content was that many important concepts in any system of classification of plants needs analysis, and the results are worth noting. The other components were effective, although they had not fulfilled the ideal time criteria. During explanations of the material, the lecturer's activities to inform and motivate students were ineffective. For this third meeting, lecturers needed to provide a great deal of information, especially regarding the similarities and differences between each of the classification systems, so that it was necessary to motivate many students to be skillful in the analysis. At the third meeting, the activities of the students and lecturers were effective, for five components for the student activities were demonstrated to be effective, whereas the results for the activities of the lecturer show that three components were effective.

At the fourth meeting, students were not effectively listening and observing explanations by their lecturers and friends, and textbook reading was still not effective. The fourth meeting, at which the topics of discussion included the collection and preparation of specimens of plants as well as the identification of plants, required a practical understanding of the material. The other components were effective, although there were components did not meet the ideal time criteria. For the lecturer's activities, all components were demonstrated to be effective, although there were two components that did not meet the ideal time criteria. At the fourth meeting, the student activities were effective, for four components relevant to student activities. As for the activities of the lecturer, they were very effective because all the components showed they were effective.

At the fifth meeting, the students were still not effectively listening and observing lecturer's and friends' explanations or effectively reading the textbook. At the fifth meeting, where discussion centered around the nomenclature of plants and the phylocode as a new nomenclature system, there was much rote content due to the discussion of many rules about nomenclature that were still new. The other components were effective, although there were components that did not meet the ideal time criteria. The components of the lecturer's activities and information, observation of student activities, as well as instruction and guiding activities were still not effective. This was likely because there was so much material to discuss regarding the rules, and the molecular nomenclature of plants was still unfamiliar. The other components were demonstrated to be effective, although they did not meet the ideal time criteria. At the fifth meeting, the students' activities were effective for four components demonstrate were effective the students' activities. As for the activities, the lecturer was quite effective because the two components showed they were effective.

At the sixth meeting, the students were still not effectively listening and observing explanations by the lecturer and friends. At the sixth meeting, the discussion was about the approaches used in plant taxonomy, which were characterized by many important concepts new to students. The other components were effective, although there were components that did not meet the ideal time criteria. The lecturer's explanation of activities and information were still not effective. This was likely because of the characteristics of the content, as was already mentioned. The other components were effective, although there was still one component that did not meet the ideal time criteria. At the sixth meeting, the students' activities were effective, because five components for the students' activities were effective. As for the activities, the lecturer can be quite effective because the four components showed they were effective.

At the seventh meeting, all components for the students' activities were effective, although there were some components that did not meet the ideal time criteria. The seventh meeting discussed the role of molecular studies in plant taxonomy in which the content had been much discussed previously in some other subjects. For the lecturer, giving instructions and guiding activities was not effective. The other components were effective, although some components still did not meet the ideal time criteria. At the seventh meeting, students' activities were effective for five components for student activities. While for lecturer activities it can be said to be effective because the four components show effectiveness.

At the eighth meeting, students were still not effectively reading the textbook. At the eighth meeting, the types of molecular markers and their application in plant taxonomy were discussed, and because this content was new to the students, students still had many questions to ask. The other components were already effective, although there were many other components that did not meet the ideal time criteria. For the activities of the lecturer, all components showed effectiveness, although they did not fulfill the ideal time criteria. The content was still associated with the seventh meeting. At the eighth meeting, the students' activities were effective five components for the student activities. As for the activities of the lecturer, they seem to be quite effective because all five components showed effectiveness.

At the ninth meeting, the students' activities were effective for all components, although there were some components that did not meet the ideal time criteria. The ninth meeting discussed Random Amplified Polymorphic DNA and its applications, which was content that was briefly discussed in the previous chapter. For the activities of the lecturer, all components were effective, although they did not fulfill the ideal time criteria. The content was still associated with that of the eighth meeting. At the ninth meeting, the students' activities were very effective for five components. As for the activity of faculty, it was very effective because the five components

showed they were effective.

At the tenth meeting, the students' activities showed they were effective for all of the components, although there were some components that did not meet the ideal time criteria. The tenth meeting was to discuss the Microsatellite Molecular Markers and their applications, which were briefly discussed in the previous chapter. For the activities of the lecturer, all components were effective, although they had not fulfilled the ideal time criteria. The content was still associated with that of the eighth and ninth meetings. At the tenth meeting, the students' activities were very effective for six components. As for the lecturer's activities, all five components showed effectiveness.

At the eleventh meeting, all the components of students' activities were effective, although there were some components that did not meet the ideal time criteria. The eleventh meeting was to discuss the types of information presented in plant taxonomy, which was briefly discussed in the previous chapter. For the activities of lecturers, all components were effective, although they did not meet the ideal time criteria. The content was still associated with previous meetings. At the eleventh meeting, the student activities were very effective for all six components of students' activities. As for the lecturer's activities, they were very effective because the five components showed they were effective. Based on the data analysis of the students' and lecturer's activities during the eleventh meeting, we can be quite sure that the use of this molecular plant taxonomy textbook for higher plant botany learning was effective.

c) Student responses to the textbook and supporting devices

Based on Table 4, the responses of the students were very positive to using textbooks and supporting devices for learning higher plant botany, because the average percentage of all variables surveyed was 93.4%. The response of students to using textbooks and supporting devices (evaluations and practical instructions) in learning of higher plant botany was very positive. It was based on the criteria that more than 90% of the students gave positive responses for 80.95%, of the number of aspects surveyed.

Table 4. The student responses data toward the textbook and supporting devices.

	Aspect	Yes	No
A	**Title**		
	1.Student interested to read	100%	0%
	2.The title can help students to predict the content of the textbook	40.5%	59.5%
B	**Preface**	100%	0%
C	**Chapter Overview**		

	1.The purpose of learning	100%	0%
	2.The instructions for studying the textbook	100%	0%
D	**Materials/Contents**		
	1.Improve to understanding of the concepts	100%	0%
	2.Improving knowledge of the science and technology	100%	0%
	3.Help to dig further information	100%	0%
	4.Enhance critical thinking	100%	0%
E	**Language and Illustrations**		
	1.The language is easy to understand.	42.2%	57.8%
	2.Textbook contents are arranged systematically	96.7%	3.3%
	3.Presentation of tables and figures according to the rules	98.4%	1.6%
F	**Summary** help to understand the essentials of the matter	100%	0%
G	**Exercise**		
	1.Demanding re-read the textbook content	100%	0%
	2.Obtaining a score above 70	93.5%	6.5%
	3.Individual task obtain additional information	100%	0%
H	**Glossary** helps to increase your mastery of concepts of plant taxonomy	100%	0%
I	**Practicum**		
	1.Practical instructions for each activity easy to understand	100%	0%
	2.Practicum activities gives more understanding about plant taxonomy	100%	0%
	3.Practicum activities about molecular studies became more understanding about plant taxonomy-based molecular approach	100%	0%
	4.Practicum training honesty, accuracy, and responsibility	100%	0%
	Average	**93.9%**	**6.1%**

d) Learning management

The assessment results from two observers who, for each meeting, judged the ability of lecturers to manage learning using taxonomy textbooks based on molecular approaches can be seen in Table 5. From the results of the observational analysis of learning management, the application of taxonomy textbooks based on molecular approaches is a good way to learn a higher level of plant botany.

Table 5. Learning management by using textbook plant taxonomy-based molecular approaches.

	Meeting	SCORE					
		Observer 1		Observer 2		Average	
		Σ	$\overline{X}$	Σ	$\overline{X}$	Σ	$\overline{X}$
1	The first meeting (March 22, 2016)	95	3.7	109	4.2	204	3.9
2	The second meeting (March 29, 2016)	108	4.2	97	3.7	205	3.9
3	The third meeting (April 5, 2016)	102	3.9	103	3.96	205	3.9
4	The fourth meeting (April 12, 2016)	108	4.2	103	3.96	211	4.1
5	The fifth meeting (April 19, 2016)	111	4.3	106	4.1	217	4.2
6	The sixth meeting (May 3, 2016)	97	3.7	92	3.5	189	3.6
7	The seventh meeting (May 10, 2016)	104	4.0	95	3.7	199	3.8
8	The eighth meeting (May 24, 2016)	104	4.0	94	3.6	198	3.8
9	The ninth meeting (May 31, 2016)	93	3.6	108	4.2	201	3.9
10	The tenth meeting (June 16, 2016)	112	4.3	107	4.1	219	4.2
11	The eleventh meeting (June 21, 2016)	106	4.8	106	4.8	212	4.8

Based on the results of data analysis on the effectiveness of the application of molecular plant taxonomy textbooks, the four effectiveness standards for textbooks (learning outcomes, student and lecturer activities, student responses, and learning management) have met those criteria. This means that molecular plant taxonomy textbooks and their supporting devices (practicum and evaluation instructions) are effective; in other words, they have met the criteria of Nieveen (1999).

Nieveen (1999) explains that learning outcomes, activities of students and lecturers, and responses are used as aspects in determining the effectiveness of the products developed. Tarigan and Tarigan (1986) explain that a quality textbook must have clear concepts, be easily understood by students, challenge students, stimulate student activities, be in accordance with interests, foster motivation to learn, have appropriate and interesting illustrations, and be relevant to the curriculum.

Conclusion

Based on the analysis that has been done, we conclude that: (a) the molecular plant taxonomy textbook met the criteria for being a suitable textbook, namely being valid, practical, and effective, and (b) supporting devices for the plant taxonomy textbook, which include practical instructions and evaluations, have also met the criteria. Molecular plant taxonomy textbook-based approaches and supporting devices (practical instruction and evaluation) resulting from this research needs to be further

developed by combining the learning of plant taxonomy or higher plant botany with a variety of innovative learning models.

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