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Development of multiple representation media for pteridophyta material to improve student learning outcomes

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Abstract

Pteridophyta material in high school tends to be delivered conventionally. This condition can hinder the achievement of students' understanding, especially at the macroscopic, microscopic, and symbolic levels. One of the efforts that can be applied to optimize the three levels of knowledge is to apply Multiple Representation-based media. Therefore, this study aims to develop Multiple Representation media on Pteridophyta material to improve student learning outcomes. This research includes Research and Development (R&D) with the ADDIE approach. Data collection techniques using interviews, observation, and validation. Research instruments used interview sheets, observation sheets, and validation sheets. The findings data were analyzed descriptively quantitatively by testing the validation and effectiveness of the developed media. The results showed that the results of the media validation test were categorized as very good, the media developed could significantly improve student learning outcomes with t_{count} of 11.116 and t_{table} of 1.697 ($t_{count} > t_{table}$) and the results of the significance of N-Gain of 0.73 with high category and able to stimulate students to ask HOTS-based questions. Thus, it can be concluded that the developed media proved feasible to be implemented in learning.

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Introduction

Pteridophyta is one of the sub-topics taught in lower plant material. The sub-topics of the discussion include Pteridophyta Phenetics and Phylogenetics, Pteridophyta Morphological Characteristics, Pteridophyta Reproduction, and Pteridophyta Utilization (Meishanti, et al., 2018). All of these topics are taught in a complete lesson. According to facts in the field, Pteridophyta material is still taught conventionally. Biology teachers tend to teach this material theoretically, so this condition is less able to optimize students' knowledge, especially at the macroscopic, microscopic and symbolic levels (Hasanah, 2014; Mokoagow, et al., 2018; Meriyana, et al., 2020).

Macroscopic representation is a representation that can be seen and observed directly. This representation is obtained through observation of phenomena that can be seen (visible) and felt by the senses or can be an experience gained daily. Microscopic representation is an abstract representation that explains simple particulates. This is closely related to the

theoretical model underlying the explanation. Meanwhile, symbolic representation is a representation to identify something symbolically in visual displays and certain symbols. The symbolic level of representation is a representation to identify identity by using qualitative and quantitative symbolic language. The entire concept of representation is integrated into the topic concept of Pteridophyta (Mulyani, 2014; Sukmawati, 2019).

One media that can optimize students' knowledge at the macroscopic, microscopic and symbolic levels is Multiple Representation-based learning media. This media presents several forms of media at one time and attributes several types of data representation according to learning needs (Pratiwi, et al., 2017). This media has many advantages, including being able to visualize material more effectively, increasing students' concrete understanding of the material being studied, and supporting students' conceptual and contextual understanding (Astuti, & Mulyatun, 2019).

Research on the development of Pteridophyta media has been carried out by previous researchers such as the development of herbarium media, booklets (Fitriasih, et al., 2019; Nisa, et al., 2021; Hanim, et al., 2022), and comics (Asra, & Hariyadi, 2021). However, research on the development of Multiple Representation media on Pteridophyta material has never been carried out by any researcher. Thus, the originality of this research lies in the subject and object of research.

This research aims to develop Multiple Representation media on Pteridophyta material to improve high school student learning outcomes. The expected learning outcomes are cognitive learning outcomes and students' scientific questioning abilities. It is also hoped that this research can contribute to adding to the literature as well as improving teachers' skills in optimizing the use of adaptive media to instill concrete understanding in students in studying Biology material, especially Pteridophyta.

Method

This research is a type of Research and Development (R&D) research using the ADDIE (Analysis, Design, Development, Implementation, Evaluation) approach. The research was conducted in May 2022 with the product trial stage carried out in class X MIPA SMA Negeri 11 Medan. The research subjects were 32 people who were randomly selected. The research instrument used an interview sheet analyzing the potential for media development and an observation sheet on student learning outcomes. Learning outcomes data were analyzed descriptively quantitatively using the one sample t test and the N-Gain significance test which was calculated based on the pretest and posttest scores. The basis for making the t test decision used is that if $t_{count} > t_{table}$. then H_0 is rejected. However, if $t_{count} > t_{table}$, then H_0 is accepted. Before conducting the T test, the research data must be Normal and Homogeneous. The normality test uses Kolmogorov-Smirnov and Shapiro-Wilk. While the Homogeneity Test uses Homogeneity Variance (Yendrita, & Syafitri, 2019). The t test and N-Gain significance were calculated using SPSS 22. The formula used to calculate the N-Gain value is as follows (Dewi, et al., 2017).

$$g = \frac{Posttest - Pretest}{Maximum\ Score - Pretest}$$

Then, the N-Gain value is interpreted through the following N-Gain gain ranges (Pratomo, et al., 2021).

Tabel 1. N-Gain Interpretation Criteria

The Magnitude of g	Interpretation
G > 0,7	High
0,3 < g ≤ 0,7	Medium
G ≤ 0,3	Low

Media is validated in three validation aspects, namely material validation, teaching material validation, and practicality validation. Validation results are analyzed using the following formula.

$$P = \frac{\sum X}{\sum X_i} \text{ X } 100\%$$

Information:
P = Validity percentage
$\sum X$ = Number of validator scores
$\sum X_i$ = The total number of ideal scores

The validation percentage results are then interpreted with the following conditions (Pratomo, et al., 2021).

Table 2. Interpretation of Media Validity Results

Percentage (%)	Category
81 – 100	Very Valid
66 – 80	Valid
56 – 65	Fairly Valid
41 – 55	Invalid
0 – 40	Very Invalid

The research steps follow the following activity flow. At the Analysis stage, an analysis of the potential for developing Multiple Representation media was carried out by interviewing Biology teachers at SMA Negeri 11 Medan and distributing questionnaires to students. At the Design stage, a media creation design is carried out by paying attention to material content analysis at macro, micro and symbolic levels, media graphic design, curriculum analysis, as well as analysis of KI, KD and learning objectives. At the Development stage, media is developed and created based on the results of a previously determined design. At the Implementation stage, product trials are carried out in learning to determine the level of effectiveness of the media being developed. At the Evaluation stage, a thorough evaluation is carried out regarding the effectiveness and follow-up of subsequent media.

Results and Discussion

Analysis Stage

Based on the interviews that were conducted, it was found that several problems were experienced by teachers when teaching Pteridophyta material. These problems can be seen in Table 3.

Table 3. Difficulties Experienced by Teachers in Teaching Pteridophyta

No.	Problems Found
1.	Teachers have difficulty presenting concrete examples of each species in the Pteridophyta material
2.	Teachers still have difficulty teaching the phylogenetics of Pteridophyta
3.	Teachers have difficulty teaching the Latin names contained in the Principles of Classification and Nomenclature of Pteridophyta sub-material
4.	Teachers have difficulty teaching examples of Pteridophyta species to study the morphological characteristics of these plants
5.	Teachers have difficulty teaching Pteridophyta reproduction, especially on the topics of heterospory and transitional ferns

Based on Table 3 above, it can be understood that Biology teachers still experience difficulties when teaching Pteridophyta material as a whole. This can happen because of the low quality of the learning media used. Biology teachers only use Power Point as a medium to convey the Pteridophyta material to students. However, the Power Point does not fully present the complete substance of the material, the material quoted does not come from valid literary sources, and there is no interactive learning series. Thus, according to the teacher's view, the use of media that can help the interactive learning process and can optimize students' knowledge structures is very necessary to teach the Pteridophyta material.

Noviati revealed that inappropriate use of media can hamper the effectiveness of learning carried out by teachers (Noviati, 2020). This is because the teacher is unable to represent the material taught, so the material is not conveyed well. Effective learning is learning that is able to utilize tools to channel messages and information optimally. So, teachers can stimulate students' thoughts, feelings and interests to achieve learning goals effectively. Because the problems experienced by teachers are problems related to using media more effectively, the solution that can be applied is to use Multiple Representation media on Pteridophyta material. Meanwhile, the results of distributing questionnaires to students can be seen in Table 4.

Table 4. Students' Difficulties in Studying Pteridophyta

No.	Problems Found
1.	As many as 87.6% of students still have difficulty memorizing the Latin language contained in the Principles of Classification and Nomenclature of Pteridophyta sub-material.
2.	As many as 78.3% of students had difficulty differentiating and analyzing each species of Pteridophyta
3.	As many as 69.5% admitted that they were less motivated to study the Morphological Characteristics of Pteridophyta due to the lack of alternative media available to represent the morphological characters of Pteridophyta
4.	As many as 83.4% of students feel bored studying Reproduction and Phylogenetic Structure of Pteridophytes because the material is complex and difficult to understand.

Based on Table 4 above, it can be seen that students tend to have difficulty studying Pteridophyta, especially in discussing the Principles of Classification and Nomenclature, Characteristics and Morphology, Reproduction and Pteridophyta Phenetics and Phylogenetics. This condition can occur because students feel bored following the lesson due to the lack of use of interactive media that can maximize students' knowledge of studying Pteridophyta material. This is in line with (Akbar, et al., 2022) who stated that learning media that is so monotonous can reduce students' motivation and learning activities, thereby reducing their

effective learning absorption capacity. Because the use of media is monotonous, namely only using Power Point, varied media is needed that can be used continuously in one learning time. One form of varied media is Multiple Representation. So, Multiple Representation is needed to study these Pteridophyta.

Design Stage

At this stage, a design was carried out to create Multiple Representation media on Pteridophyta material. Several things to pay attention to at this stage are analysis of the placement of micro, macro and symbolic levels of material, analysis of KI, KD and learning objectives, analysis of media graphic design and analysis of media design validation by material expert validators, teaching material experts and experts. practicality (teacher). The material distribution plan at the micro, macro and symbolic levels can be seen in Table 5.

Table 5. Distribution of Material at Macro, Micro and Symbolic Levels

Knowledge Level	Sub Material	Description
Macro	The Role of Pteridophyta	Describes the content of one or several Pterisophyta species which can be processed for direct use
	Morphological Characteristics of Pteridophyta	Describes the morphological characteristics and characteristics of Pteridophyta species that can be analyzed and observed directly
Micro	Phenogenetic and Phylogenetic Explanation of Pteridophyta	Explain the phenetic and phylogenetic principles of Pteridophyta sourced from various scientific literature
Symbolic	Pteridophyta Reproduction Process	Presents the metagenesis mechanism of Pteridophyta displayed through a symbolic flow diagram of Pteridophyta reproduction

According to Table 5. above, it can be seen that the macro level of knowledge in Pteridophyta material is in the form of the Role and Morphological Characteristics of Pteridophyta because this sub-material is related to observations that can be observed directly as expressed by (Khair, et al., 2020) that the macro level includes observations of a things concretely and realistically. This includes the process of utilizing Pteridophyta, color and shape which are observed directly in the morphology of Pteridophyta. Micro level knowledge includes Pteridophyta Phenogenetic and Phylogenetic Explanations because this discussion includes abstract representations depicted in graphic form and words from the Pteridophyta classification system (phylogenetics) and the morphological characteristics of Pteridophyta (phenetics). This is in accordance with (Rusmansyah, et al., 2021) that the microscopic representation mode includes discussions that are arranged in the form of words or images and graphs. Symbolic level knowledge includes representations to identify symbolic language. In this case, it includes the complex reproductive process of Pteridophyta, but is presented in the form of certain symbols or images that have complete meaning. This is in line with (Yohana, et al., 2022) that symbolic representation includes the identification of an object in symbolic language. This can be a complex explanation that is generalized into a visual display using certain symbols.

Development Stage

At this stage, Multiple Representation media is developed based on a predetermined design. Based on the results of media development, it can be seen that the media developed consists of five chapters, namely Introduction to Pteridophyta, Phylogenetics of Pteridophytes, Pteridophyta Phenetics, Reproduction of Pteridophytes, and Utilization of Pteridophytes. At the beginning of the book there is a cover and a cover page containing the author's identity as well as a foreword and table of contents. The media display can be seen in Figure 1.

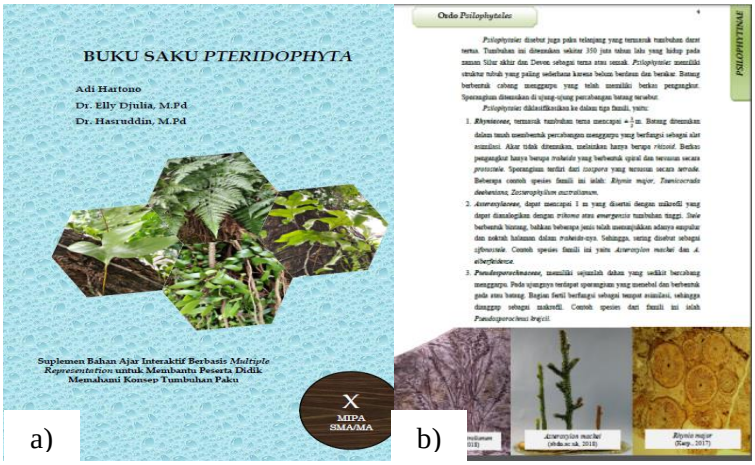

Figure 1. Display of the Pteridophyta Pocket Book Based on Multiple Representation: a) Cover and b) Material Page

The Introduction to Pteridophyta chapter contains a description of the characteristics of ferns, distribution patterns of ferns, and the life mechanisms of ferns which serve as an introduction to attract the reader's attention. This aims to enable readers to understand the general overview of the book's presentation, so that readers are more inspired to dive into the book. This is in line with that the beginning of the book should explain interesting things because this section serves to attract the reader's interest and attention to study the book in more depth.

The Pteridophyta Phylogenetics chapter presents interesting facts about the Pteridophyta classification system which is presented using a cladogram diagram. The diagram presentation is then discussed comprehensively in the next chapter, namely the Pteridophyta Phenetics chapter. This chapter explains six important components of the material, namely Description and Nomenclature of the Pteridophyta Taxon, Principles of Pteridophyta Classification, Morphological Characteristics of Pteridophytes, and Pteridophyta Habitats. This is in line with (Kurniawati, et al., 2016) that Pteridophyta Phylogenetics discusses the evolutionary development of Pteridophyta which can be presented in the form of an evolutionary hierarchy of living creatures. Meanwhile, (Suwila, 2015) emphasized that Pteridophyta phenetics are closely related to the structural characteristics of ferns which can be viewed from the morphology, taxon nomenclature and habitat of the plants.

The Pteridophyta Reproduction chapter presents a discussion of the Pteridophyta metagenesis process which is reviewed through a pictorial plot. The information contained in the image is then discussed in more detail in the moving picture which can be accessed via the video link provided. The same thing was also conveyed by that Pteridophyta reproduction is related to the reproductive cycle of ferns which forms a transition period between the vegetative and sporophyte phases or better known as the descent transition or metagenesis

cycle. This is the essence of this pocket book containing Multiple Representation because in one media package it consists of several sets of information presentations that can be accessed by students continuously.

The chapter Utilization of Pteridophyta contains a description of the content and utilization process of several Pteridophyta species. This section also includes a dry herbarium of fern species whose specific uses are discussed. This herbarium is presented with the aim that students are able to understand in concrete form the material presented. This was also conveyed by (Mumpuni, 2016) that the scope of Pteridophyta Utilization is related to the procedures for utilizing ferns carried out by the community and the presentation of the herbarium can be a concrete manifestation of the species which can sharpen students' understanding in studying the species.

At the end of the book it is also equipped with a Glossary, Questions, and Bibliography. The glossary contains definitions or brief explanations of important terms for Pteridophyta plants presented in each Chapter. The questions contain a collection of questions from the material presented to measure students' cognitive understanding. The bibliography contains a collection of literary identities that are the reference sources for the book.

After the media has been developed, the media is validated by three validators, namely the material expert validator, the teaching material expert validator, and the practicality expert validator (Biology teacher). The media validation results for each validation aspect can be seen in Table 6.

Table 6. Media Validation Results

Validation Aspect	Validity Percentage	Category
Material validation	87,65%	Very valid
Validation of teaching materials (media)	88,89%	Very valid
Practicality validation	86,66%	Very valid

Based on Table 6 above, it can be understood that the media validation results are categorized as very valid. According to (Ummi, 2018), the validity value of media in this category shows that the media developed can be used in learning. The same thing was also explained by (Tasril, & Putri, 2019) that the media validation results in the very valid category indicate that the media is suitable for use for testing in learning. Based on this, the media developed can be tested for its effectiveness in learning.

Implementation Stage

At this stage, the implementation of the media developed in learning is carried out to determine the effectiveness of the media in improving student learning outcomes. Media implementation was carried out in class X Science 1 SMA Negeri 11 Medan. At the beginning of learning, a pretest is given to determine the condition of students' initial understanding. The learning process is carried out using the Pteridophyta Pocket book which was developed through the Jigsaw Type Cooperative learning model. At the end of the lesson, a posttest was given to find out whether there was a significant influence between the conditions before and after learning using the pocket book that was developed. Apart from that, during the learning process, researchers also pay attention to and record scientific questions that arise by students to determine students' scientific questioning abilities. Media effectiveness testing activities can be seen in Figure 2.

Figure 2. Test of the Effectiveness of the Pteridophyta Handbook Based on Multiple Representation: a) Students are having a group discussion using the media developed; b) Researchers are directing students to access video links for material in the media

The average Pretest and Posttest scores can be seen in Table 7.

Table 7. Pretest and Posttest Average

Pretest	***Posttest***
1,35	18,32

Based on Table 7 above, it can be understood that the Pretest average is 1.35 and the Posttest average is 18.32. To determine the significant difference between the Pretest and Posttest scores, a one-sample t test was carried out. However, before the t test is carried out, a normality and homogeneity test is first carried out as a condition for carrying out the t test. The results of the normality test for pretest and posttest questions can be seen in Table 8.

Table 8. Pretest and Posttest Normality Test Results

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Pretest	,265	34	,037	,746	34	,085
Posttest	,130	34	,160	,932	34	,036

a. Lilliefors Significance Correction

Based on Table 8 above, it can be understood that the Kolmogorov-Smirnov and Shapiro Wilk test results are>0.05. According to (Sukestiyarno, & Agoestanto, 2017) explained that if the normality test calculation results are >0.05, it shows that the data is normally distributed. The results of the homogeneity test for pretest and posttest questions can be seen in Table 9.

Table 9. Pretest and Posttest Homogeneity Test Results

Test of Homogeneity of Variances

Levene Statistic	df1	df2	Sig.
44,462	1	66	,147

Based on Table 9, it can be understood that the test value of homogeneity of variances is >0.05**.** Homogeneity test value of >0.05 indicates that the data is the same or homogeneous. Thus, the pretest and posttest scores are homogeneous.

Because the pretest and posttest have met the parametric test requirements, namely that the data is normally distributed and homogeneous, a t test can be carried out to determine whether there is a significant difference between the pretest and posttest. Based on the t test using SPSS 22, the results obtained were Sig. (2-tailed) is 0.000, which means the value is smaller than 0.005. Furthermore, we obtained a tcount value of 11.116 with a ttable value of 1.697. This shows that the value of tcount>ttable. According to, if the tcount>ttable value indicates that there is a significant difference between the two sets of data being analyzed. Based on this, it can be understood that the posttest scores are significantly different from the pretest scores. Because the posttest score is greater than the pretest, there is a significant increase in learning outcomes by using the developed Multiple Representation-Based Pteridophyta Pocket Book.

After that, an N-Gain significance test was carried out to find out how big the difference was between students' pretest and posttest. The N-Gain significance results obtained were 0.73 in the high category. (Wahab, et al., 2021) explained that obtaining N-Gain in the high category shows that the media used is effective in achieving learning objectives because it increases learning outcomes significantly. (Rikizaputra, & Sulastri, 2020) also emphasized that the high category of N-Gain indicates that there is a very significant influence between the use of media being tested in learning on improving student learning outcomes. Based on this, it can be understood that the Multiple Representation-based Pteridophyta Pocket Book that was developed has a significant influence on student learning outcomes and has proven effective in improving student learning outcomes.

Furthermore, students' scientific abilities were also measured by paying attention to the questions that students raised during the use of media in learning. A collection of questions asked by students during the learning process using the Multiple Representation-based Pteridophyta Pocket Book that was developed is as follows.

Table 10. Collection of Questions Asked by Students

Question	Question Level	Indicator
1. What parts of Pteridophyta have the potential to be used as medicine?	C4	Examining Pteridophyta organs that have potential as medicines
2. What is the role of ferns as oxygen suppliers in the environment?	C5	Proving the role of ferns as oxygen producers by positioning these plants as components of the world's autotrophs
3. Why do Pteridophyta reproduction in the vegetative phase always use spores?	C4	Detailing the logical reasons for the role of spores in the vegetative reproductive phase of Pteridophyta
4. What is the basis for Psilotaceae being called naked fern?	C5	Validating the basic reasons why Psilotaceae are called naked ferns
5. How do the leaf characters of the 5 orders of Pteridophyta differ?	C4	Differentiate the leaf characters of the 5 orders of Pteridophyta
6. How do homosporous and heterosporous ferns differ?	C4	Differentiate the basic things that differentiate homosporous and heterosporous ferns

Question	Question Level	Indicator
7. According to the secondary metabolite compounds produced, are all Pteridophyta species efficacious as medicines?	C5	Evaluate the similarities in the use of Pteridophyta as medicine according to the secondary metabolite compounds produced

Based on the questions above, it can be understood that students have excellent scientific abilities through learning using the Pteridophyta Pocket Book that was developed. This is based on the questions asked which are oriented towards High Order Thinking Skill abilities, namely from levels C4, C5 and C6.

These HOTS level questions can be asked by students because the Pteridophyta Pocket Book based on Multiple Representation which was developed contains up-to-date material which is presented according to implementation facts, thus stimulating students to further explore the material being studied. Apart from that, the book also contains complete information about Pteridophyta starting from explanations of Phylogenetics, Phenetics, Reproduction and Utilization of Pteridophytes presented in the book. This book is equipped with scientific explanations, displays of preserved specimens that can be directly observed by students in the form of a herbarium, pictures of species that are relevant and can support the material as well as moving pictures that are integrated coherently with each other. This is what causes students to be stimulated to explore further knowledge through the questions given because it can optimize thinking abilities at the macro, micro and symbolic levels. The same thing was also expressed by (Utami, et al., 2017) that the main factor that can stimulate students' scientific questioning skills is the use of good media which can facilitate students' scientific learning. This is because students will be more aroused by their curiosity when exposed to the use of media that is rich in information substance. (Manu, & Nomleni, 2018) also reported that asking questions is an activity to develop creativity through critical thinking expressed in curiosity about the material presented through the media used. Based on this, the optimally developed Pteridophyta Pocket Book is able to facilitate the development of students' scientific, critical and creative thinking skills.

Evaluation Stage

At this stage, an overall evaluation of the development of the Multiple Representation-Based Pteridophyta Pocket Book was carried out. According to the pretest and posttest analysis, the results showed that there was a significant difference between the students' pretest and posttest, where the posttest was higher than the pretest. This indicates that there is a significant increase in learning outcomes through the use of media. Apart from that, according to the analysis of students' scientific questioning abilities, the results showed that students were able to ask questions at a scientific level well. Thus, scientifically developed media is proven to be able to improve students' cognitive learning outcomes and scientific literacy competencies.

(Treagust, 2018) emphasized that Multiple Representation-based media can improve learning outcomes because it contains facts and concepts built in macro, micro and symbolic thinking. This is able to associate students' ability to understand the material being studied effectively. Furthermore, (Rahmawati, & Mubarok, 2021) explained that Multiple Representation-based media prioritizes a constructivist-based active learning focus to increase understanding of the scientific process which consists of observing, collecting information, associating and communicating information. This is what causes students to be able to

stimulate questions related to scientific phenomena, evaluate scientific investigations, and interpret data according to scientific evidence regarding ferns.

Meanwhile, according to the teacher's response to the Pteridophyta Handbook Based on Multiple Representation which was developed, it was found that this media had explained the role and morphological characteristics of Pteridophyta well as a macro level of material. The teacher also agreed that the media developed had presented phylogenetic and phenetic explanations in a concrete manner and was easy to understand at the micro level of the material. The Biology Teacher also responded that the material on the Pteridophyta Reproduction Process in the media had been presented comprehensively and contained metagenesis symbols that were easy to understand.

According to students' responses to the Pteridophyta Pocket Book Based on Multiple Representation which was developed, as many as 31 students (91.17%) agreed that the material contained in the media was easy to understand, as many as 28 students (82.35%) agreed that the media could help in improving learning effectiveness, as many as 32 students (94.11%) agreed that the use of language in the media was presented effectively and comprehensively, as many as 33 students (97.04%) agreed that the presentation of pictures and herbaria could increase understanding related to the material being studied, and As many as 33 students (97.04%) agreed that this media was useful for increasing insight while facilitating students to develop their own potential. Thus, it can be understood that the Pteridophyta Pocket Book Based on Multiple Representation that was developed gives a positive impression and influence on the student learning process.

Multiple Representation media can have a positive influence on improving learning outcomes because this media is effective in fulfilling certain functions in learning. This media can optimize the delivery of messages and information in several channels, so that material representation can be achieved more precisely. (Ainsworth, 2020) also emphasized that Multiple Representation media can directly improve brain performance because the material is processed in various verbal/auditory or visual/image representations. Thus, brain memory works in a more complex structure and encourages meaningful learning. Overall, this is an important contribution to processing material and integrating various sources of information in a comprehensive manner. In this way, students are more facilitated to improve learning outcomes more optimally.

Conclusion

Based on the results of the research that has been carried out, it can be concluded that the development of a Pteridophyta Pocket Book Based on Multiple Representation is an important thing to improve the quality of learning in lower plant material, sub-discussion of Pteridophyta in class X Science at SMA Negeri 11 Medan. This media has fulfilled its suitability for use in learning with validation results by Material and Practicality Expert Validators in the very valid category, there is a significant increase in learning outcomes by using this media, students are stimulated to ask questions at the HOTS level, and students give positive responses to the usefulness use of developed media. This research only integrates several commonly found Pteridophyta species to become herbarium species in the media developed. Therefore, it is highly recommended for other researchers to introduce a wider range of Pteridophyta species into the media for herbarium production. This is intended to make it easier for readers to recognize fern species that are difficult to find.

Credit Authorship Contribution Statement

Adi Hartono: Conceptualization, Methodology, Software, Visualization, Formal analysis, Writing – original draft, Writing – review & editing. **Indayana Febriani Tanjung:** Conceptualization, Methodology, Formal analysis, Resources. **Jun S. Camara:** Writing – review & editing, Supervision, Project administration.

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