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Pteridophyta Herbarium Based on *Science, Technology, Engineering, and Mathematic* in Plantae Material in Senior High School

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Abstract

Observation result according to five senior high schools in Semarang was found out that Plantae material was taught with the conceptual method by using limited learning media, such as handout book and students' worksheet. Plantae material should be taught contextually by using a real object, so the students could find the concept. Contextual learning can be done by using a potential environment. One of the areas with abundant biological diversity especially ferns, located in Bukit Gentong, Kendal Regency. This diversity can be used to be learning media such as herbarium. Herbarium becomes one of the alternative learning media because it is easy to be brought, practical and effective. STEM-based arranged for herbarium media because it can be more interesting than other bases. This research's objectives are 1) to develop Pteridophyta herbarium based on STEM to accomplish basic competency of 3.8 and 4.8, 2) to analyze Pteridophyta herbarium validity a learning media, and 3) to analyze the effectiveness of Pteridophyta herbarium media concerning to students' marks. This method of this research used Research and Development by the ADDIE model. Research data consist of data validity and herbarium effectiveness, analyzed by quantitative descriptive. The result of this research show 1) Pteridophyta herbarium based on STEM media was appropriate with the basic competency of 3.8 and 4.8, 2) Pteridophyta herbarium media was very valid and suitable, and 3) Pteridophyta Herbarium media was effective to be applied in Plantae learning with students' result completeness ≥75%.

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INTRODUCTION

Plantae material is one of difficult materials to be understood by the students. Its because it has wide materials scope and the learning sources are limited. Based on the observation result of Plantae learning in five senior high schools in Semarang academic year 2017/2018 showed that learning process of Plantae still uses speech method. Only one school that use environment based learning media. Though the method had used environment, students still have some difficulties to understand this material. This is because of the learning process in that school is not provided by proper learning media according to basic competency of 3.8 and 4.8, thus their result of the study is not quite satisfied. Most of them are under minimal completeness criteria ≥75.

Learning media is important in supporting teaching and learning process. Media is used to transfer information from teacher to students. Learning media can be found from some sources, for example the students' environment. One of environments that has high potential as learning media is Bukit Gentong.

Bukit Gentong is located in Kendal Regency, it has ferns diversity that potentially to be learning media. Learning media is a solution to overcome any problems of teaching and learning process. It is because learning media can optimize learning process. Learning media can increase students' motivation and interest. It also can make them uderstand concept easily (Susilo, 2015 and Ariyanto *et al.,* 2018). According to Jonathan *et al*. (2017), the application of learning media can increase education standard. One of the medias that can be developed is herbarium.

Herbarium is a solution in Plantae material learning because it is easy to be brought, practical, and can be used effectively in learning process. Besides, the usage of herbarium can minimize the time learning, because the students do not need to in field (Nisaa *et al*., 2019). Herbarium also can overcome the lacking problem of plants availability in dry season. Because of that, herbarium media needs to be provided in learning process as the real media, thus the students can easily learn. The usage of herbarium in learning process can make the students focus and increases students' interest (Murni *et al*., 2015).

Herbarium is arranged by using *science, technology, engeneering, and mathematic* (STEM) approach. Science is main aspect that integrated into information related to ferns, so that it can stimulate students' curiousity. Technology, technique and Mathematics are used to design product to be interest, secure and easy to be brought. STEM approach is used to get interesting products and to increase students' thinking ability critically. This is also stated by Susanti *et al*. (2018) and Stohlman *et al*. (2012) that showed STEM based on learning media is very attractive, it makes the learning process becomes valuable and stimulate students' cognitive ability.

Based on the previous explanation, the aims of this research is to find out Pteridophyta herbarium based on STEM media was approvriate and valid to conduct. The objectives of this research were 1) to develop Pteridophyta herbarium based on STEM media due to the research result, 2) to analyze Pteridophyta herbarium based on STEM media validity, and 3) to analyze Pteridophyta herbarium based on STEM media effectiveness.

METHODS

This research was a *Research and Development* with *Analysis, Design, Development, Implementation, and Evaluation* (ADDIE) model (Branch & Dousay, 2009). The procedure of this research consist of five steps, they are analysis, design, development, implementation, and evaluation.

Analysis step included analysis of students' needs and kinds of potential ferns in Bukit Gentong, Ungaran Mount. Interview was used as an instrument in students' needs analysis and kinds of ferns analysis was done by observation in the area.

Design step was a step to design the developing product. The product was developed by STEM bases. Science was used to make a good herbarium and covered by mold. Beside that, science was also implemented in the product as information to increase students' curiousity. Technology was applied in designed technique concept. It was used in the making process of herbarium, for example in the process of drainage technique using wattle and in the packing of product. Mathematics was applied to get product which easy to be used.

The product was developed according to the design. After that, validity test should be done to the material and media validator. Validity could also be done in two biology teachers and 25 students of tenth grade. After product validation, product improvement was done based on suggestions, so that the product would be better. Valid and proper product would be implemented to the students to find out its effectiveness. Herbarium product implementation was done in two classes of tenth grade students using *One Group Pretest-Posttest design*. After that, there was evaluation to find out the product effectiveness based on completeness of students' learning result (summative evaluation).

RESULTS AND DISCUSSION

To fulfill the objective of the research, qualitative and quantitative data was applied. The result of this research are: 1) herbarium media characteristics, 2) media validity of validator and small scale of try out, and 3) effectiveness of herbarium Pteridophyta.

Characteristics of Pteridophyta Herbarium Based On STEM

This research produced herbarium with characteristics: herbarium was completed by general knowledge about ferns, ferns phylogeny, information about completed specimen with height of the place where it was found, and the status of conservation. The content of herbarium had been suited with basic competency of 3.8 and 4.8, it was based on students' necessity. Beside that, the herbarium was completed with pictures to make clear about imperfect specimen and show ferns habitat. Learning media that was completed by pictures is more interesting and it makes students are not bored (Munawwaroh *et al*., 2018).

Herbarium consisted of ferns diversity that was found in Bukit Gentong, with information about morphology characteristics, classification, habitat and conservation status. These information could help students to understand the description of ferns, so that they could classify ferns according to its division or family. Herbarium was also provided by determination key to help students in identifying ferns. This was appropriate with basic competency of 3.8 attached in syllabus, while basic competency of 4.8 could be seen in the herbarium

phylogenetic chart. It was arranged due to the ferns that was found.

STEM based on Pteridophyta herbarium is learning media which is designed to adjust students' sources, so they can understand the material easily and increases students' thinking ability critically. This is also stated by Bahrum *et al*. (2017) integrated STEM handout can stimulate students' knowledge and ability. Beside it, STEM approach is meant to create interesting product. Handouts should have good impression to make students desire to learn (Jannah *et al*., 2018). Herbarium STEM elements could be seen from its content and design. Science elements were in the herbarium, it was knowledge information which stimulates students' curiosity. The product of technique and Mathematics could be seen from the herbarium design in photo album sized 24x34 cm, so it could be brought and used easily.

Pteridophyta Herbarium Validity by Material and Media Experts

Herbarium validity was done by evaluation of content and design. The result based on all aspects produced valid criteria (Table 1).

Table 1. Research result by material expert and media design

Validator	Evaluated aspect	Research result (%)	Criteria
Material	Material properness	84.38	Very valid
	Herbarium component	85.00	Very valid
	Serving properness	93.75	Very valid
	Language properness	91.67	Very valid
Median		88.70	Very valid
Media	Graphic	96.88	Very valid
	Herbarium compenent	100.00	Very valid
	Languange properness	91.67	Very valid
Median		96.18	Very valid

The result of STEM based on Pteridophyta herbarium media by material and media experts showed strong validation criteria. It was because this media was arranged based on National Standard Education Organization (BSNP) handout criteria. According to BSNP (2014) good handout should be fulfilled some criterias, such as material, language, serving, and graphic properness.

Concerning to material validator evaluation, all evaluation aspects got valid criterias, although there was one of them that has lower precentage than 85,00%, in the material properness criteria. Herbarium material was suitable to basic competency which wanted to be achieved, even though there was inappropriate subject with the development of Biology. This subject potentially gave different perception to the students, so they became confused. One of solutions was given by improving that subject. Based on BSNP (2014) and Susilo (2015), students' learning material should be aware with the material properness, referring to basic competency and learning objectives. Media should have explicit material content so it could be delivered in effective way (Istifarida *et al*., 2017).

Herbarium components got very valid criteria in 85,00%. It could not get maximum score because there were some conservative plants which did not have complete parts (such as root, stem, leaf, and spora). This was caused by the time of specimen taking, those plants could not

produce spora or their size were quite big, because of this the root part could not be participated. Murni *et al*. (2015) states big sized conservative plants could be folded. Plants' description should be completed with pictures. They could make the material became clear, stimulate students' thinking and make the plants' morphology clear (Jannah *et al.*, 2018, Rezeqi & Handayani, 2018).

Presentation aspect and language component got more than 90,00% with very valid criteria. It meant that herbarium presentation was quite good. It was seen from the component and quality of herbarium. Herbarium had complete components such as morphology characteristics, classification, advantages, and habitat. Location, pictures and information of the specimen were arranged and based on alphabet neatly. Herbarium has good quality, because it does not have any mold, smell and learning easy to be used. Learning media should be secure and effective for students (Sobirin *et al*., 2013).

Herbarium was arranged with direct language, could be understood and had consistency of using science terms. Herbarium material was also arranged to be suited for senior high school students' cognitive. The language should be presented well, so the aim could be accepted (Jannah *et al*., 2018). Presentation aspect and language component were important aspects in evaluation, because these aspects could attract students' interest and it could help them to understand the material. This was also stated by Rezeqi & Handayani (2018), interactive language could make audience does not get bored. Although language aspect was still very valid criteria, there were some words should be improved, because it was not consistent.

Based on the result of media validator evaluation, herbarium component aspect got the maximum percentage, because herbarium was neatly arranged in sequence (based on alphabet and class), easy to used and brought. This was also stated by Afifah *et al*. (2014) and Susilo (2015), that learning media should be developed securely, easy to be used in learning process and it does not give any danger.

Graphic component aspect consisted of cover design and content design. Graphic component got 96,88% with very valid criteria. The cover was designed with ferns background, so it could give the description of herbarium content. Besides the letter size and location in cover design were compatible, the title was inappropriate so that it should be improved. The design was interesting, because all components were arranged harmoniously and proportionally. Graphic component was important thing in media evaluation, because it could attract students' interest. This was also stated in the research of Imtihana *et al*. (2014) that students are more interested in arranged design and attractive pictures.

Small Scale Product Test

Herbarium test in small scale was done to 2 Biology teachers and 25 students of tenth grade (Figure 1). This test was aimed to find out herbarium display and readability.

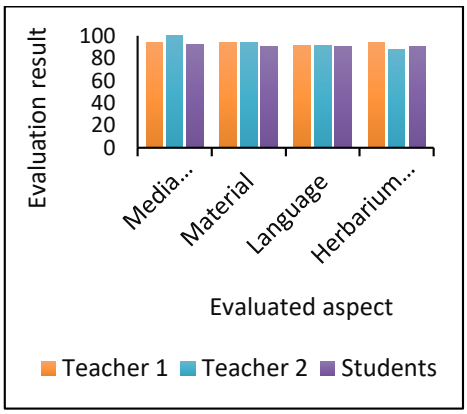

Figure 1. Teachers and students' respond

Based on teacher and students' evaluation, all aspects which were tested on herbarium media got proper criteria. Herbarium was suitable for the material and it had attractive display. According to the students, it was interesting because there were real plants that completed by any pictures. Students and teachers had not used herbarium media before, so the students were enthusiast and excited with this media.

The result of herbarium media evalution by teachers and students was very proper. However, there was aspect that got percentage under 90,00%, in herbarium quality. Based on two teachers, there was plants specimen which were not neat because of folded parts. But, these folded parts were meant to show the leaves part of under and upper surface, so that spora could be seen. Beside that, the folding was done by big sized specimen. Murni *et al*. (2015) also stated that speciment which have big size can be folded.

Herbarium quality aspect was tested from its practical and security. It got very proper criteria. This result was appropriate to the material and media experts. Herbarium was designed and packaged based on its size, so that it was easy to be used and brought. Beside that, the specimen did not have smell, so it did not disturb the students in learning process. Afifat *et al*. (2014) and Susilo (2015) stated that good media is easy to be used, brought, and it does not give any danger when it is being used in learning process.

Herbarium language aspect evaluation got very proper criteria. The language used was understandable because it used effective and direct sentences. Simple and communicative sentences could make the students understand the material easily and attracted students' interest. Media should be arranged in good language so it could be understood (Paramita *et al*., 2018). However, there were students that could not understand some of sentences though the criteria was very proper. The difficult sentences should be replaced with the easy ones without change the material content.

Material aspect evaluation could be seen from some indicators, they were basic competency properness, material completeness, material easiness, and material presentation techniques. Pteridophyta herbarium based on STEM had fulfilled the basic competency and Plantae material completeness. Material on the Pteridophyta herbarium media could be understood by the students because the sentences were simple and clear and the material was systematic.

Pteridophyta Herbarium Base on STEM Media Effectiveness

Effectiveness of using Pteridophyta herbarium based on STEM could be showed from the students' learning result. This learning result, consist of on three points, which were cognitive, affective, and psychomotor. Cognitive result was seen by they posttest, affective was seen by students' attitude during the observation and disscusion, psychomotor was seen by students' skill and result of the observation report. Students' cognitive result could be presented on Figure 2.

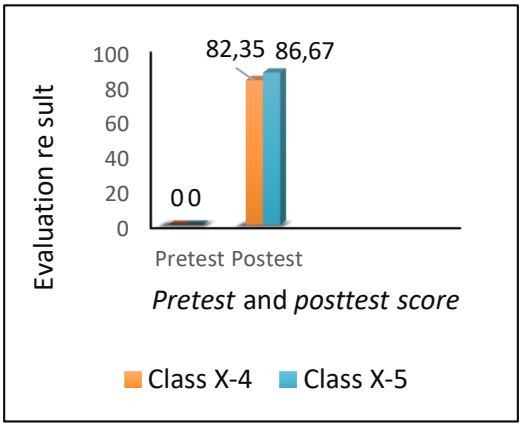

Figure 2. Cognitive learning result completeness

Based on the classical completeness, students' cognitive result in X-4 and X-5 ≥ 80,00%. It meants' Pteridophyta herbarium media was effective to increase their cognitive result. Herbarium Pteridophyta was effective because the media was arranged according students' needs and suited to material Plantae in basic competency of 3.8. It was classifying plants into division based on their general characteristics that were observed and relating it to daily life. Beside that, herbarium was arranged based on the students' environment, so they could be more understood and related the material to their daily life. Jannah *et al*. (2018) stated that learning material is more meaningful if it is appropriate with the school environment. Specimen as a learning media could increase learning quality because it make the teachers deliver material concept and easily make also the students learn unprovided object easily (Yelianti *et al*., 2016).

Herbarium usage in learning process could be done contextually to give students' direct experiences. They do not only listened to their teachers' explanation they also involved in observation process and identified ferns. This activity made the students find material concept, so they could comprehend the material based on they observed. Learning experience from this activity make the material save in students; long term memory (Mulyani, 2017). Beside that, direct learning could ease the students in accepting material and increasing their science skills (Istiani & Retnoningsih, 2015 and Baihaqi *et al*., 2015). However, there were any students who had not mastered the material, as a result, their score were under standard. Group learning caused some of students could not be independent and they relied on others, so it made them became passive and forgot the material concept.

Beside increasing students' cognitive result, herbarium could also increase students' activities and abilities. Students' activities could be seen from their affective result. Based on their affective result analysis, the students in X-4 and X-5 have good and very good score category. It was showed that using herbarium in learning process could increase students' interest and activities. The usage of learning media could stimulate students' motivation, learning interest and their achievement, it also eased them to comprehend the material (Susilo, 2015 and Purnamasari *et al*., 2012). Students' activities that observed can be seen on in the learning process were listening to the material and paying attention to the explanation, their curiousity, cooperative, responsibility and respecting each other (Figure 3).

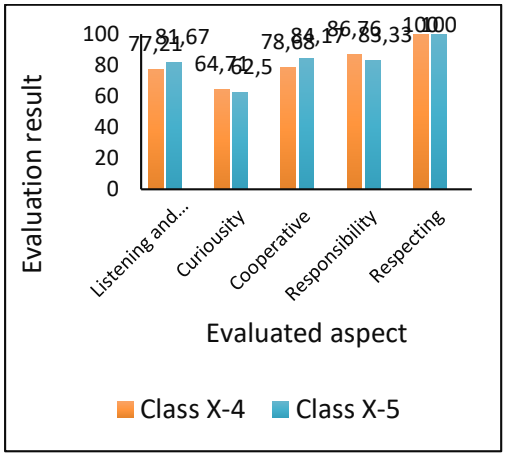

Figure 3. Students' activities

Based on students' affective result analysis, it showed that respecting aspect had the highest percentage. Respecting others could be seen when the students did group and class discussion. Group activity gave them chance to express their opinions and share it to make a deal. Respecting others was also showed in class discussion. Students expressed their opinions in turn and respected other opinions.

The usage of Pteridophyta herbarium in group could increase their cooperation and responsibility. They worked together to identify ferns morphology characteristics and analyze the result, also discuss them related to their daily life. Group discussion activity could increase students' cooperation in solving problems. This activity make the students to be responsible. Students tried to take their responsibility to their tasks that given by their groups in presenting observation result. The usage of herbarium in learning process effects to students' learning activity and increases their cooperation in the class (Maulana & Ulfa, 2016).

The lowest aspect in percentage was curiousity. Most of the students had big curiousity. For example, they tried to find out kinds of ferns in their school environment and morphologycal structure by using herbarium. But there were students who were lack of curiousity. Observation result showed only some students who asked questions and expressed their opinions. It was because the students did not have confidence, so they did not give any respond or even asked something. Their lack of confidence made them to be passive in learning process because they did not show how their ability was (Nirwana, 2013).

The usage of Pteridophyta herbarium in learning process could stimulate the students' skills. The skills can be increase are observing and presenting report skill (Figure 4). The research from Sulistiyarsi (2010) showed that using herbarium media in learning process could increase students' achievement, affective, and psychomotor.

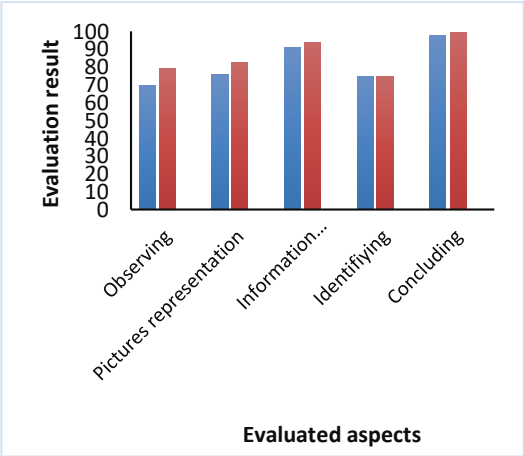

Figure 4. Students' ability

Skill of conclusion making got the highest percentage among others. It was because the students understood how to make good conclusion. The conclusion was appropriate to the objectives of research and observation data. Although there were some students presented the report incorrectly.

The lowest aspect was identifying skill. The students found difficulties in ferns identifying. This ability was new experience to them, so they fell difficult to do. New skill that do by students need time to get used to, so the students can be skilled (Nisa & Sulinayah, 2014). This problem faced by the students in identifying was their difficulty to use determination keys.

CONCLUSION

Pteridophyta Herbarium based on STEM was arranged based on basic competency of 3.8 and 4.8 to fulfill students' needs. Herbarium media was very valid and proper as validator,

teachers and students, so it was effective to be used in learning process.

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