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Development *STEM E-Booklet* Curug Winong Fern Plants as a Student Learning Resource

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ABSTRAK
Penelitian ini bertujuan untuk mengetahui jenis tumbuhan paku yang ada di Curug Winong dan hasil uji kelayakan produk E-booklet dari hasil penelitian. Penelitian ini menggunakan metode Research and Development dengan ukuran trap 4 x 4 m. Hasil identifikasi tumbuhan paku tercatat 39 jenis tumbuhan paku yang terbagi dalam 17 famili, 6 ordo, dan 3 kelas. Persentase dominan terlihat dari perhitungan INP tertinggi yaitu *P. Biaurita* dan *S. Ornate*, sedangkan nilai INP yang terendah adalah *A. Evecta* dan *G. Verrucosum*. Indeks keanekaragaman tumbuhan di Curug Winong termasuk kriteria sedang. Hasil validasi ahli materi (77,78%), media (96,13%), tanggapan guru (91,67%), uji tumpang tindih (83,66%), dan tanggapan siswa (83,90%). Hasil tersebut menunjukkan bahwa *E-booklet* yang dikembangkan layak digunakan sebagai sumber belajar.
Kata kunci: *Curug Winong; E-Booklet; Sumber Belajar; Tumbuhan Paku.*

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ABSTRACT
This study aims to determine the types of ferns in the Curug Winong and the results of the E-booklet product feasibility test from the research results. This research uses the Research and Development method with a size trap of 4 x 4 m. The results of the identification of ferns recorded 39 species of ferns which are divided into 17 families, 6 ordo, and 3 classes. The dominant percentage can be seen from the highest INP calculation, namely P. Biaurita and S. Ornate, while the exposed INP values are A. Evecta and G. Verrucosum. The index of plant diversity in Curug Winong is of moderate criteria. The results of the validation of material experts (77.78%), media (96.13%), teacher responses (91.67%), overlap test (83.66%), and student responses (83.90%). These results indicate that the E-booklet that was developed is suitable to be used as a learning resource.
Keywords: *E-booklet, Fern, Learning resources, Winong Waterfall*

INTRODUCTION

Ferns are seedless vascular plants that have the widest distribution with more than 12,000 species (Campbell *et al*. 2012: 179). Ferns have several important roles, namely in forming humus, protecting the soil from erosion, maintaining soil moisture,

and are one of the pioneer plants in the early stages of forest ecosystem succession. The economic value of ferns lies in their beauty. Ferns act as bioindicators of soil cation concentrations in rainforests (Zuquim *et al*. 2014) and several species from the genus Microsorum (Metuapuaa) have been used for traditional medicine (Delos & Bout, 2012).

Ferns are often found in areas with high humidity such as tropical rainforests, mountainous areas and waterfall areas. Environmental factors such as air temperature, light, humidity and air and soil. This fern can grow in swampy areas, mangroves and mountains that have high humidity and high rainfall (Katili, 2013). .

Curug Winong is one of the waterfall areas in Wonosobo Regency. The Curug Winong area has an area of 2 Ha with a waterfall height of 100 m (wonosobokab.go.id). The height of the Curug Winong area reaches 650. Van Steenis (2010) said that ferns usually grow more near waterfalls. However, learning activities outdoors to a place has quite a big challenge in its implementation. Good planning is needed starting from permits to learning activity scenarios at that location. Teachers or school officials have difficulty determining implementation times and controlling students. Biorge *et al* (2017) said that the time provided by the curriculum and classroom management is a challenge for teachers to carry out learning outside the classroom. Learning outside of school requires costs, means of transportation, energy and guaranteed safety for students, as well as the possibility of disruption to other class hours at school.

Ferns are one of the topics discussed in the Plantae material. Interviews conducted with biology teachers at SMA N 1 Kaliwiro located in Wonosobo Regency showed that 75% of students had difficulty distinguishing between the gametophyte and sporophyte phases in fern metagenesis and did not know the benefits of ferns for life. This is supported by Zarisma's research et *al.* (2016) of 38 students, only 33.33% of students answered correctly regarding the characteristics of ferns and 38.89% of students answered correctly regarding the metagenesis of ferns. Research data can be a supplement to support teaching materials that are contextual, interesting and up-to-date (Imtihana *et al*. 2014).

The results of biological research are useful for providing up-to-date knowledge about the conditions around students' environments. In fact, there is still little use of research results as a learning supplement. One similar development was carried out by Ristiani (2021) who developed a booklet on the Diversity of Ferns in the Kembang Soka Waterfall Tourist Attraction Area, Kulon Progo Regency as a Learning Resource. The development carried out certainly has its own differences and novelty. The development of the E-booklet is a development based on the needs of students at SMA N 1 Kaliwiro and data on the diversity of ferns is taken from the natural riches in the area. Apart from that, the update is in the form of packaging booklets in electronic form which are packaged based on a STEM approach*(Science, Technology, Engineering, and Math)* Of course, this is different from developments that have been carried out previously. Andaresta & Rachmadiarti (2021) concluded *Ebook* STEM-based ecosystem material to train scientific literacy skills was stated to be very valid

theoretically and empirically in terms of student responses, getting a result of 99.27% in the very positive category.

Research results can be used as an interesting learning resource by packaging them in all learning media that are in line with technological advances. Based on considerations of learning obstacles and difficulties, developing learning media is considered necessary for students at SMA N 1 Kaliwiro. The existence of media can visualize something abstract to become more concrete, bring difficult or dangerous objects into learning situations, shorten the development process which takes a long time. The media used as visualization so that the learning environment can be included in the classroom are *E-booklet* with STEM elements *(Science, Technology, Engineering, and Math)* based on mobile *learning.* Learning media using e-booklets developed from research results is a suitable, practical and efficient learning media to be used as a learning resource (Oktafiani *et al*. 2022) and more effectively train creative, communicative and collaborative thinking skills with high criteria (Kurniahtunnisa & Wowor, 2023). Based on the background above, research is needed to explore the diversity of ferns in Curug Winong and determine its feasibility *E-booklet* research results as a source of learning fern material for students.

METHOD

This type of research is a modified Research and Development (R&D) research from Sugiyono (2017: 298). The R&D method refers to the ADDIE model which is used to produce certain products and test the effectiveness of these products. The research began by identifying the diversity of ferns in the Curug Winong area by making transect lines measuring 4 x 4 m. Calculation of fern diversity was calculated using the Shannon-Wiener formula. Next, the data obtained is developed into a product, namely *E-booklet*. The development model developed by Sugiyono (2017: 298) which has been modified, has several stages, namely, preliminary study, data collection, product design, design validation, design revision, small-scale trials, product revision.

RESULTS AND DISCUSSION

RESULTS

The results of fern identification at two observation stations showed that 39 types of ferns were recorded which were divided into 17 tribes, 6 nations and 3 classes (Table 1).

The Importance Value Index of an area shows the importance of a type of fern in the community. The INP value of ferns is obtained from the accumulation of Relative Dominance (DR) and Relative Frequency (FR). In this study, each station explored showed different types with the highest INP (Table 2).

The results of research on ferns that were obtained from research in the Curug Winong area were developed into an *E-booklet*. The *E-booklet* diversity of Curug Winong ferns developed has been validated by material experts, media experts and biology teachers at SMAN 1 Kaliwiro. Material and media experts assess feasibility components based on their expertise. The teacher assesses all eligibility components *E-booklet* because the teacher will later use it *E-booklet* as a supplement to direct learning in the classroom. Validation results are presented in Table 3.

Table 1. Types of Ferns at Curug Winong

Ethnic group	Number of types	Type	Station	
			1	2
Aspleniaceae	2	*Asplenium macrophyllum*	✓	✓
		*Asplenium*sp.	✓	✓
Athyriaceae	1	*Diplazium*sp.	✓	✓
Blechnaceae	1	*Blechnum orientale*	✓	✓
Davalliaceae	1	*It would denticulate*	✓	✓
Dryopteridaceae	2	*Irregular pleocnemia*	✓	✓
		Polystichum sp.	✓	✓
Gleicheniaceae	1	*Dicranopteris linearis*	✓	✓
Lindsaeaceae	2	*Lindsaea ensifolia*	✓	✓
		Tapeinidium pinnate	✓	✓
Lygodiaceae	1	*Lygodium flexuous*	✓	✓
Marattiaceae	1	*Angiopteris raised*	✓	✓
Marsileaceae	1	*Marseilles crenate*	✓	✓
Nephrolepidaceae	1	*Nephrolepis biserrata*	✓	✓
Polypodiaceae	6	*Belvisia spicata*	✓	✓
		Drynaria quercifolia	✓	✓
		Goniophlebium verrucosum	✓	✓
		Phymatosorus membranifolium	✓	✓
		Pyrrosia adnascens	✓	✓
		Pyrrosia piloselloides	✓	✓
Pteridaceae	7	*Adiantum neat*	✓	✓
		Adiantum hispidulum	✓	✓
		Adiantum lunulatum	✓	✓
		Adiantum Raddianus	✓	✓
		Pityrogramma calomelanos	✓	✓
		Pteris biaurita	✓	✓
		Pteris ensiformis	✓	✓
Salviniaceae	2	*Azolla pinnata*	✓	✓
		Salvinia swimming	✓	✓
Selaginellaceae	3	*Selaginella ornate*	✓	✓
		Selaginella plana	✓	✓
		*Selaginella*sp.	✓	✓
Tectariaceae	5	*Stenosemia* sp.	✓	✓
		Tectaria melanocaula	✓	✓
		Tectaria plantaginea	✓	✓
		Tectaria zeylanica	✓	✓
		Tectaria zollingeri	✓	✓
Thelypteridaceae	2	*Christella dentate*	✓	✓
		Macrothelypteris torresiana	✓	✓

Table 2. Five Dominant Types at Station 1 and Station 2

Station 1	INP	Station 2	INP
P. biaurita	16,19	*S. ornate*	23,75
S. ornate	14,18	*P. biaurita*	22,19
C. dentate	14.14	*P. calomelanos*	20,90
St. swimming	13,79	*A. lunulatum*	19.12
A. hispidulum	11,79	*S. flat*	12,48

Table 3. Validation Results *E-booklet*

No	Validator	Percentage	Criteria
1.	Material validation	77,78%	Worth it
2.	Media validation	96,13%	Very worthy
3.	Teacher response	91,67%	Very worthy
4.	Test the gap	83,66%	Very worthy
5.	Student response	83,90%	Very worthy

DISCUSSION

The Pteridaceae family has the most members, namely 7 types, this is because the types of ferns from the Pteridaceae family are ferns that are able to grow in open and dry areas to humid and shaded areas at a certain height (Muswita, 2013). This is in accordance with the conditions at Curug Winong, where most members of the Pteridaceae can be found at both observation stations.

The type with the highest Importance Value Index at station one is *P. biaurita* (16,19) and the type with the lowest index is*A. raised* (1.42). Research results from Rukmana (2018) show that*P. biaurita* is a type of fern found in all habitats, *P. biaurita*is a type of the Pteridaceae family. This shows that Curug Winong is a suitable location for growth *P. biaurita.* Research results from Darma *et al.* (2018) *A. raised* is a type of nail that has a low FR value of 2.73%. This is because this type grows well in the temperature range between 19-27^{O}C (Hartini, 2015). The temperature at station one was measured at 27^{O}C which is the maximum threshold for growth of *A. Raised.* This causes growth spikes *A. raised* not good at Station one. Calculation of the INP value for station two, the type with the highest value, namely *S. ornate* (23,75) and the lowest type is *G. verrucosum* (0.94) Overall, the type that has the highest INP value in the Curug Winong area is *S. ornate*. This shows that this species has the largest number of individuals and is most often found in the research plot.

Station one is the entrance to the waterfall. This station consists of a large area of rice fields and fields used to plant snake fruit trees so that it has a fairly dense canopy. Rice fields are a suitable habitat for types of water ferns such as *St. Swimming* An abundance of individuals will create a community *St. swimming* in rice fields. This will make the nail the dominant type and have a large DR value. *S. ornate* is a type of fern that has the highest FR value. This type can be found in almost every research plot at the station.

Station two is a waterfall area which has lots of rocks on the river banks. This waterfall is surrounded by albizia and pine forests so it has a fairly dense canopy. At this station *S. ornate* can be found very abundantly so it has a high DR value and *P. Biaurita* is a type of fern that can be found in almost every observation plot so it has a high FR value. The high and low DR and FR values of a species indicate that the environmental conditions are suitable for the growth and development of that type of fern (Hutasuhud, 2018). High DR or FR values cannot yet be said to mean that the fern species is dominant in an area. Ferns can be said to dominate an area if the number of individuals is abundant and can be found in every research plot, which indicates that the environment is suitable to support the growth of ferns.

The composition of the five types of ferns at each station, some types of ferns spread in closed areas and some types grow in open areas in low areas. *Pteris biaurita* is a type of fern that is able to live in habitats ranging from lowlands to highlands (Yudhayana, 2013). As well as *P. biaurita,* type *P. calomelanos* is a fern that lives in less dense shade from the lowlands to a certain height (Astuti *et al.* 2018). Ethnic group*Selaginella* has a high tolerance for the environment. Apart from that, this type of nail has the ability to compete with other types (Wong 2010).*S.ornate* is a type of fern that lives in closed areas. Setyawan & Sugiyarto (2015) explained that this type of fern requires a lot of water for growth and reproduction, so this plant is often found living in damp areas such as springs, mountain slopes, rivers and damp cliffs. Therefore, *S. ornate* It is often found in the Curug Winong area because this place is close to springs and has high humidity.

Type *A. hispidulum* and *A. lunulatum* is a type of nail known as suplir. Sukrasa *et al.*(2011) said that this type of plant lives in moist, shaded areas. These types of suplir have the ability to produce many spores and can spread with the help of wind and water. This is what causes these two types to be found in abundance and spread widely in the Curug Winong area. The differences in fern types found will affect the diversity index (H'), evenness (E), and composition similarity (IS) at the two observation stations. The data recapitulation can be summarized as in Table 4.

Table 4. Recapitulation of Diversity, Evenness and Similarity Indexes

Index	Station 1	Station 2
H’	2.988	2.913
E	0.525	0.460
IS	**68.96%**	

Information:
H’ : Species diversity index
E : Species evenness index
IS : Type similarity index

Analysis results using indices *Shannon-Wiener* shows that the diversity index of fern species at both stations is categorized in the medium category (1<H'<3). The diversity values at the two stations respectively are 2.99 and 2.91. In line with diversity, the evenness index for both stations is in the medium category (0<E<1). Moderate

diversity is due to the fact that there are several more types of ferns that are dominant than other types in a community and the uneven distribution of fern types. Factors that influence the high and low diversity at Curug Winong are environmental conditions such as microclimate and also disturbances either natural or due to human activities.

The similarity index is used to see similarities in the composition of ferns. The calculation results show that the two stations have a similar species composition of 50%<Is<75%. The similarity of types is influenced by environmental factors which are relatively the same at both stations. The diversity index at both stations did not show significant differences. This is because both stations have almost the same environmental factors, so the plant composition is not much different. If the species composition in the two areas being compared is almost the same, it indicates that there are no very prominent environmental differences between the two places (Umar, 2013). Similar environmental factors in both places will influence the ferns that grow in both locations. This can be seen in the similarity index which shows that the two locations have similar types of ferns with a percentage of 65%. In line with the diversity index, the evenness index shows the medium category at both locations. The diversity index value is influenced by the evenness index value. If a community consists of evenly distributed species, the community will have moderate to high diversity (Fachrul, 2007: 51).

The height of the place will influence other environmental factors. The higher an area, the temperature and humidity will decrease. Khan *et al. (*2011) explains that the higher the place, the fewer plant species there will be due to changes in temperature and humidity which are getting colder. Winong Waterfall has a temperature range of 26-27^{O}C, is the optimum temperature for some ferns such as*P. biaurita, C. dentata, P. irregularis, P. membranifolium,*and *N. Bisserta* (Nawawi *et al.* 2014). Humidity will affect soil pH. Lubis (2009) states that moist soil has a low pH, while dry soil tends to have a high pH. Winong Waterfall has a pH range of between 6.3 – 6.8 which is categorized as the optimum pH for the growth of ferns. Ferns that are often found at low pH include the Adiantum genus and the Pteris genus. Meanwhile, ferns that prefer alkaline pH include *Selaginella* sp*, P. piloselloides, T. plantaginea, Pyrrosia adnascens* and other types characterized by epiphytic living in open rock areas. The degree of acidity or pH influences nutrient absorption and growth, including the influence of toxic substances and nutrient moisture. Most ferns grow well in soil with an acidic pH of between 5.5-6.5, but in rocky areas ferns require a more alkaline pH, namely 7-8 (Sandy *et al.* 2016).

Soil moisture cannot be separated from the influence of sunlight intensity. High humidity indicates that the light intensity of an area is low. Low light intensity will affect the growth of nail types, especially those that require high light intensity, such as *D. linearis. D. linearis* is a type of nail that grows in open places (Holtum, 1966). The low intensity makes the soil moist which will create suitable environmental conditions for other types of ferns and so on *D. linearis* will disappear.

Environmental factors will influence the composition of ferns at Curug Winong. This composition will create high species diversity. The species diversity index (H') is

used to measure community stability, namely the ability of a community to maintain itself stable despite disturbances to its components (Sulastri *et al.* 2019). A community is said to have high species diversity if the community is composed of many species. A community is said to have low species diversity if the community is composed of few species (Tujudki *et al.* 2014). The medium category indicates that the Curug Winong area has a relatively stable community and has the potential to experience better stability.

Apart from being carried out by biology experts and teachers, feasibility assessments are also obtained from students through student response questionnaires. Feasibility assessment *E-booklet* by students carried out during small-scale trials. The assessment sheet *E-booklet* refers to the 2014 BNSP regulations which have been modified. The components assessed in assessing the suitability of the material include the dimensions of knowledge, language and presentation techniques. Aspects assessed in the knowledge dimension include the relevance of learning objectives to Basic Competencies, material accuracy, and contextual material. The validator's assessment obtained a high percentage value of 83.3%. Presentation of material *E-booklet* begins by introducing the Curug Winong area. Next, introduce ferns by describing the kinship scheme of ferns, general morphology, the habitat of several ferns, and the similarities and differences between ferns and other plants. After the reader gets to know ferns, observational data from research conducted at Curug Winong is presented, material regarding the life cycle of ferns is presented, followed by the role of ferns for life and the environment. With this, it can be said that the presentation in *E-booklet* coherent.

Further validation in terms of media was validated by media experts from Semarang State University. The aspects assessed include software engineering aspects and audio-visual communication aspects. The components assessed from the first aspect are effectiveness and efficiency, reliability (reliability/program can run smoothly),*maintainable* (can be maintained/managed easily), usability (easy to use and simple in operation), compatibility (learning media can be run on various software and hardware), media program packaging, and reusable (part or all of the learning media program can be reused to develop other learning media). The validation results of the software engineering aspect obtained a percentage value of 96.43%.*E-booklet* developed is in very good criteria.

E-booklet used as an alternative medium for studying fern material. Media *E-booklet* runs on a smartphone with the Android operating system. At the moment, *smartphone* is an item that is familiar to every student. Research conducted by Saputra (2017) stated that almost 96% of students were familiar and used to using smartphones. *E-booklet* developed in the form of an application mobile *learning* that adapts to applications that are widely used by students. Sukiman (2012) believes that there is *E-booklet* This can be used to clarify the presentation of material so that it can increase learning motivation and be able to overcome space and time limitations so that students will be more effective and efficient. *E-booklet* which was developed is easy for students to use with simple navigation so it is easy to understand for readers

who are using it for the first time. Amirullah & Hardinata (2015) in their research stated that media that has a clear, neat appearance and has good quality in the aspects of writing, software engineering and appearance are characteristics of good media. The following displays the E-booklet that has been developed.

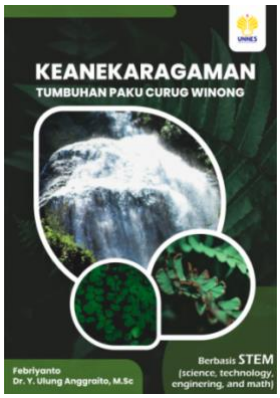

Figure 1. E-booklet cover

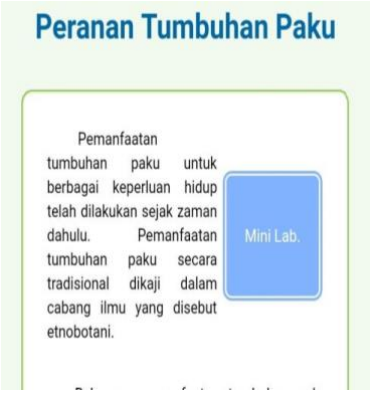

Figure 2. Location of navigation for additional student activities

Figure 3. Main Menu Display

Figure 4. Image Layout Design

Overall *E-booklet* The one developed has the advantage of being able to be installed on smartphones which are based on Android and does not require a lot of RAM, making it easier for students to carry media. Navigation is easy to use, practically applied during learning, the application design is attractive, and uses language that is adapted to student development so that it is easy to understand and is able to arouse students' interest in learning about ferns through media. *E-booklet.* Apart from that, this e-booklet combines elements of STEM*(Science, Technology, Engineering, and Math)* as an additional approach to learning. The existence of STEM will increase student activity in collaborating between the knowledge, technology and skills they have to hone students' creative thinking abilities. Research results from Jauharriyah (2017) concluded that STEM-based learning can train and improve scientific literacy, motivation, understanding of material, creative thinking skills, effectiveness, meaningful learning, and support future careers. Assessments by experts and teachers received an average percentage of 88.53% with appropriate criteria. Therefore *E-*

booklet developed has met the feasibility standards according to BNSP in 2014. This is supported by research from Sulastri *et al.* (2019) who received a percentage of 81% in developing a fern module in the Muncar Wonogiri Temple area as a learning resource.

A small-scale trial was carried out on sixteen students of class X MIPA SMAN 1 Kaliwiro with different ability levels. The small-scale trial aims to determine the level of readability *E-booklet* and student responses to *E-booklet*. Students are asked to fill in a gap test, which is a written test technique to test students by filling in the gaps in a discourse. The gap test is used as a measure of readability *E-booklet* which has been developed. The gap test obtained an average percentage of 83.66% with high criteria. This is proven by the percentage of students with low ability levels of more than 60%. This is supported by research results from Kairil *et al.* (2016) who concluded that the gap test is an effective technique for determining the readability level of teaching materials.

In addition, students were asked to fill out a response questionnaire regarding *E-booklet* which was developed. Filling out the questionnaire aims to find out students' responses to *E-booklet* which was developed. The average percentage value obtained from the small scale student response questionnaire was 83.90% with good criteria. Good criteria by students shows that the E-booklet developed is suitable for use as a high school biology learning resource. *E-booklet* The development results certainly have shortcomings and limitations. These limitations include operating the application having to use an internet network, if the internet quality is not good then the process of displaying images on *E-booklet* will be a little longer. There is *E-booklet* Curug Winong ferns is expected to provide new insight into the biological richness and beauty found in Curug Winong, so that students become aware of increasing their caring attitude towards the environment so that biodiversity, especially ferns, is maintained.

CONCLUSION AND RECOMENDATION

Based on the research results, it can be concluded as follows

The results of research on the diversity of ferns at Curug Winong identified 39 types of ferns consisting of 17 tribes, 6 nations and 3 classes. The diversity of Curug Winong is in the medium category, dominated by species *S. ornate* at the first station and *P. biaurita* at the second station. Furthermore, the E-booklet on the diversity of Curug Winong ferns that has been developed has obtained the criteria for being suitable for use as a biology learning supplement, especially fern material for class , student response was 83.90%, and readability of the E-booklet by students was 83.66%.

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REFERENCES

Amirullah, G. & R. Harinata. (2015). Pengembangan *Mobile Learning* bagi Pembelajaran. *Jurnal Kesejahteraan Keluarga dan pendidikan*. Volume 4(2): 97- 101.

Andaresta, N & Rachmadiarti, F. (2021). Pengembangan E-Book Berbasis Stem Pada Materi Ekosistem Untuk Melatihkan Kemampuan Literasi Sains Siswa. *Jurnal Berkala Ilmiah Pendidikan Biologi*. Vol 10(2): 635-646

Astuti, F. K., Murningsih., Jumari. (2017). Keanekaragaman Jenistumbuhan Paku (Pteridophyta) Di Jalur Pendakian Selo Kawasan Taman Nasional Gunung Merbabu, Jawa Tengah. *Jurnal Biologi.* Volume 6(2): 1-6.

Biorge, S., T. Hannah., P. Rekstad, & T. Pauly. (2017). *The Behavioral Effects of Learning Outdoors*. Retrieved from Sophia, the St. Catherine University.

Campbell N A, J B Reece, L A Urry, M L Cain, S A Wasserman, P V Minorsky, and R B jackson. (2012). *Biologi Jilid 2 edisi 8 (alih bahasa).* Jakarta: Erlangga.

Darma, I. D. P., W. S. , A. Priyadi., R. Iryadi. (2018). Paku Epifit dan Pohon Inangnya di Bukit Pengelengan, Tapak dan Lesung, Bedugul, Bali. *Jurnal Penelitian dan Konservasi Alam.* Volume 15(1): 41-50.

Delos, A. M, & I Buot. (2012). Orders and Families of Philippine Pteridophytes. *Journal of Nature Studies*. Volume 11 (1&2): 19-33.

Fachrul, M. F. (2007). *Metode Sampling Bioekologi*. Jakarta: Bumi Aksara.

Holttum RE. (1966). *A. Revised Flora of Malaya*: *Vol. II, Ferns of Malaya.* Singapura (SG): Government Printing Office.

https://wonosobokab.go.id/website/index.php/berita/mitra-pemkab/item/102-wisata-alam diakses pada tanggal 1 Februari 2019, pukul 21.33 WIB.

Hutasuhud, M. A. (2018). Keanekaragaman Tumbuhan Herba di Cagar Alam Sibolangit. *Klorofil*. Volume 1(2): 69-77.

Imtihana, M., Martin, F P., Priyono, B. (2014). Pengembangan Buklet Berbasis Penelitian Sebagai Sumber Belajar Materi Pencemaran Lingkingan Di SMA. Unnes Journal of Biology Education. Vol 3(2): 186-192.

Jauhariyyah, F. R., H. Suwono., Ibrohim. (2017). Science, Technology, Engineering and Mathematics Project Based Learning (STEM-PjBL) pada Pembelajaran Sains. *Pros. Seminar Pend. IPA Pascasarjana UM*. Volume 2: 432-436.

Katili. (2013). Deskripsi Pola Penyebaran Dan Faktor Bioekologis Tumbuhan Paku (Pteridophyta) Di Kawasan Cagar Alam Gunung Ambang Kawasan Kabupaten Bolaang Mongondow Timur. *Jurnal. Saintek.* Volume7(1): 35-41.

Khairil., Salam., A. F. Junus. (2016). Keterbacaan Wacana dalam Buku Teks Bahasa Indonesia “Ekspresi Diri dan Akademik” Cetakan Kedua Melalui Cloze Test Siswa Kelas X SMA 1 Makassar. *Jurnal Retorika*. Volume 9(1): 33-39.

Khan, S. M., D. Haeper., S. Page., H. Amad.(2011). Species and Community Diversity of Vascular Flora Along Environmental Radient in Naran Valley: a Multivariate Approach Through Indicator Species Analysis. *Journal Botany.* Volume43(5):2337-2346.

Kurniahtunnisa & Wowor, E C. (2023). Development of STEM -ProjectBased Learning Devices to Train 4CSkills of Students. *Bioeduca: Journal of Biology Education.* Vol 5 (1): 66-78

Lubis, S.R. (2009). *Keanekaragaman dan Pola Distribusi Tumbuhan Paku di Hutan Wisata Alam Taman Eden Kabupaten Toba Samosir Provinsi Sumatera Utara.* Tesis. Universitas Sumatera Utara. Medan.

Muswita, P M., Indama., M. E. Sanjaya. (2013). Studi Keanekaragaman Jenis Tumbuhan Paku di Taman Nasional Bukit Duabelas Provinsi Jambi. *Jurnal Prosiding Semirata FMIPA Universitas Lampung.* hal: 1-6.

Nawawi., Indriyanto. & Duryat. (2014). Identifikasi Jenis Epifit dan Tumbuhan yang Menjadi Penopangnya di Blok Perlindungan dalam Kawasan Taman Hutan Raya Wan Abdul Rachman. *Jurnal Sylva Lestari.* Volume2 (3): 39-48.

Oktafiani, R,. Retnoningsih, A., Widiatiningrum, T. (2022). Pengembangan E-Book Interaktif Tumbuhan Berbiji dengan Pendekatan Saintifik dan Kontekstual. *Bioeduca: Journal of Biology Education*. Vol 4(1): 67-83.

Ristiani, H I. (2021). Pengembangan Booklet Keanekaragaman Tumbuhan Paku di Kawasan Objek Wisata Air Terjun Kembang Soka Kabupaten Kulon Progo Sebagai Sumber Belajar. Journal Of Biological Education. Vol 1(2): 73-82.

Rukmana, E. (2018). Keanekaragaman Tumbuhan Paku Terestrial pada Tiga Jenis Ekosistem di Taman Nasional Gunung Ciremai. *Tesis.* Bogor: Institut Pertanian Bogor

Sandy, P., Hudha. & Latifa. (2016). Keanekaragaman Jenis Tumbuhan Paku (*Pteridophyta*) di Kawasan Air Terjun Lawean Sendang Kabupaten. Malang. dalam: *Prosiding Seminar Nasional II Tahun 2016*. Malang

Saputra, G. E. A. (2017). Pengaruh *Smartphone* terhadap Aktivitas Belajar Siswa Kelas X SMA Muhammaddiyah 7 Yogyakarta. *Naskah Publikasi.* Yogyakarta: Universitas Muhammadiyah Yogyakarta.

Setyawan, A. D. & Sugiyarto. (2015). Diversity of Selaginella in Bromo Tengger Semeru National Park, East Java. *Pros Sem Nas Masy Biodiv Indon*. Volume. 1 (6), 1312 -1317.

Sugiyono. (2017). *Metode Penelitian Kuantitatif, Kualitatif dan R&D*. Bandung: Alfabeta

Sukiman. (2012). *Pengembangan Media Pembelajaran.* Yogyakarta: Pedago.

Sukrasa., Aprilian , H., Chasanah, T. (2011). Diversity Species Tumbuhan Paku hias dalam Upaya Melestarikan Sumberdaya Hayati Kebun Raya Baturraden. *Biosfer.* Volume 28 (1).

Sulastri., T. Wiharti., A.A Nugroho. (2019). Keanekaragaman Tumbuhan Paku di Kawasan Wisata Alam Candi Muncar Wonogiri sebagai Bahan Penyusunan Modul Pembelajaran. *Journal of Biology Learning.* Volume 1(1): 25-35.

Umar, R. (2013). *Ekologi Umum*. Universitas Hasanuddin: Makassar.

Van Steenis, C.G.G.J., A. Hamzah, & M. Toha. (2006). Flora Pegunungan Jawa. *Pusat Penelitian Biologi-LIPI,* Bogor.

Wong K. M. (2010). *Selaginellaceae.* Di dalam: Parris BS, Kiew R, Chung RCK, Saw LG, Soepadmo E, editor. *Flora of Peninsular Malaysia; Ferns and Lycophytes* Vol 1. Kepong, Selangor Darul Ehsan (MY). Forest Research Institut Malaysia 52109.

Yudhayana, A.(2013). 3500 *Plant Species of the botanical Garden Indonesia*. Jakarta: LIPI.

Zarisma, U., Q. Mahwar., & D. M. Nuri.(2016). Identifikasi Kesulitan Belajar Peserta Didik pada Materi Dunia Tumbuhan Kelas X SMA Negeri 1 Sambas. *Jurnal Biologi Education*. Volume 3(2): 33-41.

Zuquim, G., H. Tuomisto., M.M. Jones., J. Prado., F.O.G. Figueiredo., G.M. Moulatlet., F.R.C. Costa., C.A. Quesada, & T. Emilio. (2014). Predicting environmental gradients with fern species composition in Brazilian Amazonia. *Journal of Vegetation Science*. Volume 10:1-1