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The Effectiveness of the Pteridophyta Diversity E-Module in the Sikarim Waterfall Area as a Biology Teaching Material on the Cognitive Learning Outcomes of Grade X Students

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ABSTRAK

Tujuan dari penelitian ini adalah sebagai berikut: 1) mengetahui apa saja jenis jenis tumbuhan paku (*Pteridophyta*) yang ada di kawasan Air Terjun Sikarim. 2) Mengetahui kelayakan e-*modul* sebagai bahan ajar biologi siswa. 3) Menganalisis keefektifan *e-modul* terhadap hasil belajar kognitif siswa. Metode penelitian yang digunakan adalah *Research and Development* (R&D) model 4D. Pada tahap *disseminate* dilakukan uji coba skala kecil dengan desain *one group pretest post-test.* Subjek dalam penelitian ini adalah siswa kelas X-7 SMAN 1 Mojotengah. Hasil penelitian ini menunjukan bahwa *e-modul* berbasis potensi *Pteridophyta* di Kawasan Air terjun Sikarim layak digunakan sebagai bahan ajar pada materi keanekaragaman hayati, dengan perolehan nilai dari ahli materi sebesar 93,22% dan ahli media sebesar 87,17% serta pengisian tanggapan dari peserta didik sebesar 82,22% dan tanggapan guru sebesar 95,57%. Keefektifan *e-modul* terhadap hasil belajar peserta didik dilihat berdasarkan nilai *N-Gain*. Hasil perhitungan menunjukkan terdapat perbedaan hasil *pretest* dan *post-test*. Peningkatan hasil belajar peserta didik dikategorikan tinggi dengan *N-Gain* sebesar 0,789. Oleh karena itu, dapat disimpulkan bahwa *e-modul* berbasis potensi *Pteridophyta* di Kawasan Air terjun Sikarim layak serta efektif digunakan sebagai bahan ajar biologi materi keanekaragaman hayati.
Kata kunci: E-Modul, *Pteridophyta*, Air Terjun Sikarim, Keanekaragaman Hayati, Hasil Belajar Kognitif

ABSTRACT

The objectives of this research are as follows: 1) find out what types of ferns (Pteridophyta) exist in the Sikarim Waterfall area. 2) Knowing the suitability of e-modules as biology teaching materials for students. 3) Analyze the effectiveness of e-modules on students' cognitive learning outcomes. The research method used is Research and Development (R&D) 4D model. At the dissemination stage, a small scale trial was carried out with a one group pretest post-test design. The subjects in this research were class X-7 students at SMAN 1 Mojotengah.The results of this research show that the e-module based on the potential of Pteridophyta in the Sikarim Waterfall Area is suitable

for use as teaching material on biodiversity material, with scores obtained from material experts of 93.22% and media experts of 87.17% as well as filling in responses from participants students amounted to 82.22% and teacher responses amounted to 95.57%. The effectiveness of e-modules on student learning outcomes is seen based on the N-Gain value. The calculation results show that there are differences in the pretest and post-test results. The increase in student learning outcomes is categorized as high with an N-Gain of 0.789. Therefore, it can be concluded that the e-module based on the potential of Pteridophyta in the Sikarim Waterfall Area is feasible and effective for use as biology teaching material on biodiversity.
Keywords: *E-Module, Pteridophyta, Sikarim Waterfalls, Biodiversity, Cognitive Learning Outcomes*

INTRODUCTION

Indonesia's strategic position between the continents of Asia and Australia is one of the factors that makes Indonesia the center of diversity in the world, and is known as a megabiodiversity country (Tamaela et al., 2020). Triyono (2013) explains that Indonesia's location on the line 06o N - 11o S and from 94o E - 141o E causes the Indonesian archipelago to have a tropical climate. Having a tropical climate means that it only has two seasons, namely the rainy season and the dry season, where the temperature, rainfall and humidity are very suitable for various types of living things. As we know, Indonesia's tropical rainforests are known as the forests that are richest in plant species and have the most complex ecosystems in the world (Efendi, 2013). One example of a very important diversity and including pioneer plants and supporters of flora diversity is ferns.

The tropical climate conditions in Indonesia supported by geographical aspects around the equator cause ferns to be widespread and found in many places (Meganingrum, 2022). Betty (2015) explains that ferns are easily recognized by their morphological characteristics, but many still cannot distinguish them from other plants. Ferns (Pteridophyta) can live in various habitats, both terrestrial, epiphytic, and aquatic. Ferns are one of the vascular plants whose bodies have 3 main parts, namely roots, stems, and leaves, and have the main reproductive organs, namely spores (Marpaung, 2019). The characteristic of this plant is that it has young leaves that roll up called circinnatus (Ruma & Nomnafa, 2010).

The diversity of ferns (Pteridophyta) is very diverse. This is evidenced by data on the number of fern species where Indonesia has at least 1300 identified Pteridophyta species (Andries, Koneri, & Maabuat, 2022). According to Bawaihaty, Molvray, & Photo (2017) the diversity and abundance of these plants vary depending on environmental conditions, including altitude. Altitude provides variations in microclimate, especially air humidity. One area that has a lot of fern diversity is the Sikarim Waterfall area. Sikarim Waterfall is located on the Dieng Plateau between Mount Bisma and Mount Sikunir at an altitude of 1,800 meters above sea level. Precisely in Mlandi Village, Garung District, Wonosobo Regency (Hagar, 2022).

Based on observations and interviews that have been conducted, biology learning at SMA Negeri 1 Mojotengah has not maximized the use of the environment as a learning resource. The learning process of biodiversity material that has been carried out so far is by observing certain plants that are already known to teachers and students. The delivery of material is carried out using conventional methods and the teaching materials used in Biology learning are printed teaching materials from one publisher. The biology teacher at SMA Negeri 1 Mojotengah also explained that the use of gadgets at SMAN 1 Mojotengah is around 60-70% but unfortunately e-modules have not been utilized in biology learning.

The existence of Pteridophyta in the Sikarim Waterfall area as a local potential has not been fully utilized as a learning resource. Utilization of local potential can be used to introduce the diversity of Pteridophyta plants in the student's area, so that students know the diversity of plants in their surrounding environment (Meganingrum, 2022). The natural potential used in the learning process is intended to provide contextual understanding so that it can create applicable and meaningful learning, and students can understand the wisdom in the area where they live (Marlina, 2013). In accordance with the statement of Andira, Noorhidayati, & Riefa (2021) that the environment is a natural laboratory that presents unique phenomena that humans must study so that it can bring students closer to their learning objects.

The diversity of Pteridophyta in the Sikarim Waterfall Area has the potential to be a learning resource that is packaged into teaching materials in the form of interesting e-modules on Biodiversity material. The use of e-modules that can be accessed via digital devices in the form of Android applications can make it easier for students to learn because they can be used anytime and anywhere, both offline and online (Syahiddah, Putra & Supriadi, 2021). The advantages of e-modules include increasing the effectiveness and flexibility of learning, making the learning process interesting and not easily boring (Surjono, 2019). The development of e-modules on Biodiversity can be used as a complement to teaching materials, making it easier for students to learn independently because they can be used outside of class hours, and increasing students' insight because they are compiled using sources from potential that exist in nature (Putra, Wirawa & Pradnyana 2017).

Based on these conditions, it is necessary to find a solution to the problem, one of which is by developing teaching materials in the form of e-modules based on local potential. The goal is to find out what types of ferns (Pteridophyta) are in the Sikarim Waterfall area, to find out the feasibility of e-modules as biology teaching materials for students, to analyze the effectiveness of e-modules on students' cognitive learning outcomes..

METHODS

This type of research is a mixed method research consisting of descriptive exploration, R&D (Research and Development). Descriptive exploration is direct observation of facts in the field. In this stage, the researcher will systematically identify the observed objects, namely the identification of Pteridophyta diversity in the

Sikarim Waterfall area using various references. Determination of samples was carried out using purposive sampling techniques by selecting one species from the population that has the best morphological characteristics. Sampling using the 2m x 2m square plot method totaling 6 plots.

The R&D model chosen is the 4D model, because it is systematic and easy to understand and very suitable for the development of learning devices, one of which is e-modules. The 4D model developed by Thiagarajan (1974), consists of 4 stages of development, namely define, design, develop, and disseminate. The analysis stage is the stage of initial analysis, student analysis, curriculum analysis and material analysis. The design stage is the stage of designing the cover and contents of the e-module that is created. This design stage goes through several activities, namely making a concept map, formulating materials, and making a format. The development stage is the stage of developing an e-module. This stage also includes a validity test of the biology e-module based on local potential on the material of biodiversity. The validity assessment of the e-module by 4 validators consisting of 2 biology education lecturers and 2 high school biology teachers. The disseminate stage is the stage of distributing the e-module. At this stage, a small-scale trial was carried out with a one group pretest post-test design research design. The subjects of this study were students of class X-7 at SMAN 1 Mojotengah.

The research instruments were in the form of biology teacher interview sheets, observation sheets for Pteridophyta observations, material and media expert validation sheets to assess the validity of the module, student and teacher response sheets and test instruments. Descriptive data were converted into quantitative values with a calculation scale of 1-4 as shown in table 1. Table 2 is a table containing the e-module eligibility criteria..

Table 1. Changing Qualitative Values to Quantitative Values

No	Qualitative Analysis	Statement Score	
		Positif	Negatif
1.	Strongly agree	4	1
2.	Agree	3	2
3.	Not Agree	2	3
4.	Strongly Not Agree	1	4

Tabel 2. Eligibility Criteria

Average Score (%)	Category
80 < skor ≤ 100	Very Worth It
60 < skor ≤ 80	Worthy
40 < skor ≤ 60	Quite Decent
20 < skor ≤ 40	Less Worthy
0 < skor ≤ 20	Not feasible

The analysis of the effectiveness of the e-module is calculated based on the N-Gain value obtained from the results of the pretest and posttest of students. The N-gain test analysis was carried out with the help of SPSS 26 software. The results of the n-gain calculation were then converted into categories in table 3 as follows

Tabel 3. Kategori Konversi N-Gain

Nilai (g)	Kategori
0,7 ≤ (g)	Hight
0,3 ≤ (g) <0,7	Currently
(g) < 0,3	Low

RESULT AND DISCUSSION

In this study, there are two research results, namely the results of the identification of Pteridophyta in the Sikarim Waterfall Area, the results of the e-module feasibility, and the effectiveness of the e-module on cognitive learning outcomes.

Pteridophyta Identification Results in the Sikarim Waterfall Area

In the explorative stage, identification of Pteridophyta in the Sikarim Waterfall Area was carried out to determine the diversity of ferns. The results of the identification of Pteridophyta found that there were 17 species of Pteridophyta classified into 5 orders. This identification of Pteridophyta used the help of the Google Lens application, PictureThis, and the book Plant Taxonomy (Schizophyta, Thallophyta, Bryophyta, Pteridophyta) (Tjitrosoepomo, 2016), and online portals (www.pteridoportal.org and powo.science.kew.org). The results of the identification in the Sikarim Waterfall Area were then validated by Pteridophyta species experts for the truth of each species. The species expert validator is one of the lecturers of Biology Education, Tidar University. The following are the results of the identification of ferns that have been validated by species experts.

The existence of high diversity of fern species in the Sikarim Waterfall Area is due to environmental factors (abiotic) that are in accordance with the life of various types of ferns. Based on the results of exploration in the Sikarim Waterfall Area, it can be seen that the Polypodiales order has the most species found than other species. This is influenced by more significant spore dispersal than other orders. If spore dispersal is high, the abundance of Pteridophyta is also high. In accordance with Saputro's statement (2020) that spore dispersal in Pteridophyta is the main key to the number of Pteridophyta that will grow.

Another reason for the dominance of the Polypodiales order is because this order is the largest Pteridophyta order in Indonesia. around 80% of the total Pteridophyta in Indonesia are the Polypodiales order (Akbar, 2023). In addition, the Polypodiales order has a wide distribution area on the earth's surface, especially in forest areas with high humidity (Nurchayati, 2017). It can be seen that the Dieng Plateau area is included in the humid class humidity category, so it is suitable for the growth of Pteridophyta (Mukofa, 2007). The results of the identification of Pteridophyta in the Sikarim Waterfall Area can be seen in table 4.

Table 4. Classification of Pteridophyta in the Sikarim Waterfall Area

No	Ordo	Famili	Genus	Spesies
1	Polypodiales	Thelypteridaceae	Christella	*Christella parasitica* (L.) Holttum
			Cyclosorus	*Cyclosorus interruptus* (Willd.) H. Ito
		Davalliaceae	Davallia	*Davallia trichomanoides* Blume
		Nephrolepidaceae	Nephrolepis	*Nephrolepis biserrata* (Sw.) Schott
				Nephrolepis cordifolia (L.) C. Presl
		Polypodiaceae	Pyrrosia	*Pyrrosia angustata*
		Pteridaceae	Pteris	*Pteris vittata* L.
		Lindsaeaceae	Osmolindsaea	*Osmolindsaea odorata* (Roxb.) Lehtonen & Christenh
		Dennstaedtiaceae	Pteridium	*Pteridium aquilinum* (L.) Kuhn
		Blechnaceae	Blechnum	*Blechnum orientale* Burm
		Pteridaceae	Pityrogramma	*Pityrogramma calomelanos* (L.) Link
2	Gleicheniales	Gleicheniaceae	Dicranopteris	Dicranopteris linearis (Burm.) Underw
			Sticherus	*Sticherus truncatus* (Willd.) Nakai
3	Selaginellales	Selaginellaceae	Selaginella	*Selaginella kraussiana* (Kunze) A. Braun
				Selaginella doederleinii Hieron
4	Marattiales	Marattiaceae	Angiopteris	*Angiopteris evecta* (G.Forst.) Hoffm.
5	Lycopodiales	Lycopodiaceae	Lycopodium	*Lycopodium cernuum* L

The types of Pteridophyta found at the research location mostly belong to the Polypodiales order. The general characteristics of this order are that the leaves have various shapes, single or compound with free or adjacent leaf veins. The shape of the sorus varies (stripes, elongated or round), located on the edge of the leaf, and can also be in the form of leaf veins (Sarah, 2023). Based on the research results, there are 8 families included in the Polypodiales order, including Thelypteridaceae, Davalliaceae, Pteridaceae, Nephrolepidaceae, Polypodiaceae, Lindsaeaceae, Dennstaedtiaceae and Blechnaceae. These families have characteristics that distinguish them from other families..

The Thelypteridaceae family has general characteristics, namely creeping upright rhizomes and small brown scales. The leaves are single to double pinnate. Sori are round and elongated at the leaflet veins covered by indusium (Halimatussadiah, 2023). The types of Pteridophyta found and included in this family are Christella parasitica (L.) Holttum and Cyclosorus interruptus (Willd.) H. Ito. The Davalliaceae family has general characteristics, namely creeping rhizomes or rhizomes, reddish brown hair, and no thorns. Has a double or more pinnate leaf shape. Sori are in the form of elongated round pockets, found on the underside of the leaves or on the edges of the leaves (Musriadi, 2017). This is in accordance with the results of research related to the types of Pteridophyta included in the Davalliaceae family, namely Davallia trichomanoides Blume.

The Pteridaceae family has general characteristics, namely creeping, upright, curved rhizomes, generally scaly, rarely with hairs, brown or black scales. Most leaves are monomorphic, slightly dimorphic, clustered or spread far apart. Sporangia are generally long-stalked, spores are brown or yellowish (Sianturi, 2020). This is in

accordance with the results of research related to the types of Pteridophyta included in the Pteridaceae family, namely Pteris vittata L and Pityrogramma calomelanos (L.) Link. The Nephrolepidaceae family has general characteristics, namely having monomorphic, numerous and pinnate leaves. Short or upright creeping rhizomes, scaly, and can produce tubers. Can be terrestrial or epiphytic plants. Sori are round or oval (Shofiyati, 2019). Nephrolepidaceae usually grow in clumps, young leaves roll up, and the shape of the leaves is like a sword that is tightly arranged (Rizkiani, 2019). In this study, the plants belonging to the Nephrolepidaceae family were Nephrolepis biserrata (Sw.) Schoot and Nephrolepis cordifolia (L.) C. Presl.

The Polypodiaceae family has general characteristics, namely single leaves arranged on short stems, hairy roots with a dark brown color. There are no stems above the ground, only rhizomes that are often scaly. Sorus is evenly distributed on the lower surface of the reddish brown leaves and has an indusium (Taslim, 2019). The Lindsaeaceae family has general characteristics, namely short rhizomes, some are long and creeping and covered with scales or hair. The leaf blades are pinnate. Plants in this family are more terrestrial fern plants, rarely climbing or epiphytic. (Imaniar, 2017). This is in accordance with the type of Pteridophyta found, namely Osmolindsaea odorata (Roxb.) Lehtonen & Christenh.

The Dennstaedtiaceae family has general characteristics, namely creeping rhizomes, somewhat upright, covered with a few stiff hairs. The leaf blades are pinnate. Spores are on the underside of the leaves and are tightly clustered (Dermawan, 2016). This is the same as the type of Pteridophyta found in the study, namely Pteridium aquilinum (L.) Kuhn. The Blechnaceae family has general characteristics, namely having a simple leaf shape, large leaf appearance and rough and wide textured leaves. Creeping or upright rhizomes. Sorus on both sides of the leaf veins protected by indusium (Sianturi, 2020). Based on the study, the species Blechnum orientale Burm was found which is included in the Blechnaceae family.

The Gleicheniales order has general characteristics, namely sorus not covered by indusium with a small number of sporangia. Sorus is located on the abaxial part of the leaf, opening with one longitudinal slit and a transverse oblique annulus (Sarah, 2023). Gleicheniales is one of the terrestrial Pteridophyta that has roots in the form of creeping rhizomes. The leaves are pinnately forked or pinnate. It has round sorus, rolled leaf tips and has scales (Yuliana, 2021). Based on the research results, the types of Pteridophyta included in the Gleicheniales order are Dicranopteris linearis (Burm.) Underw and Sticherus truncates (Willd.) Nakai.

The Selaginellales order has general characteristics such as creeping stems and some have an upright stature, forked branches, growing upwards and elongated shoots that can reach several meters (Wahyuni, 2022). According to Tjitrosoepomo (2014), the Selaginellales order also has microphyllous leaves or leaves that are small and tightly arranged. Sporophylls are usually collected in a series of sporophylls in the form of grains located at the tip. The types of Selaginella found are Selaginella kraussiana (Kunze) A. Braun and Selaginella doederleinii Hieron.

The Marattiales order has general characteristics of large leaf size (Macrophylls), double pinnate, and has sporangia on the underside of the leaf with thick walls and no annulus (Yuliana, 2021). Based on the research results, the type of Pteridophyta included in the Marattiales order is Angiopteris evecta (G.Forst.) Hoffm. Angiopteris evecta has a large stature so it is called the "king of fern".

The Lycopodiales order has general characteristics of stems with simple vascular bundles, growing upright or lying down with branches that tower upwards, leaves with hairs in the form of lines or needles and forked roots (Sugiarti, 2017). Based on the results of the study, Pteridophyta included in the Lycopodiales order are Lycopodium cernuum L.

Feasibility of the Pteridophyta Diversity E-Module in the Sikarim Waterfall Area

a. Define

The define stage consists of four analyses, namely initial analysis, student analysis, curriculum analysis, and material analysis. Initial analysis is carried out to identify and determine the basis of the problem that underlies this research. Based on observations and interviews with biology teachers at SMA Negeri 1 Mojotengah, the results showed that learning on biodiversity material has utilized local potential as a learning resource but has not been maximized. The teaching materials used in learning only use textbooks and LKPD. Through interviews and observations, it can be seen that students are less enthusiastic when learning activities are carried out using conventional methods. In addition, because the teaching materials used are also less interesting, not based on local potential and the use of smartphones is not optimal in the learning process.

After analyzing the needs and characteristics of students, the next stage is the curriculum analysis stage. The curriculum analysis stage is carried out through interviews with Biology teachers, the curriculum used in class X is the Independent Curriculum. At this stage, an analysis of Learning Achievements (CP) in biology subjects is carried out, then the Learning Objective Flow (ATP) is formulated. The CP and ATP that have been compiled are included in the e-module on Pteridophyta Diversity in the Sikarim Waterfall Area. In making teaching materials, compliance with CP and ATP is very important because it is used as a guideline in making them (Kartikawati, 2022). Furthermore, it is necessary to carry out a material analysis, namely describing the biodiversity material so that the learning objectives that will be included in the e-module being developed can be identified. Learning objectives include 1) describing Indonesian Biodiversity by presenting a report on the results of observations in the surrounding environment. 2) Describing the benefits of Biodiversity by presenting a report on the results of a study of the benefits of certain species in the surrounding environment. 3) Classifying Biodiversity in the surrounding environment based on a certain classification basis.

b. Design

This stage is the design stage of the e-module for the diversity of Pteridophyta in the Sikarim Waterfall Area. This stage consists of the activities of compiling the material framework and compiling the e-module format. The material in the e-module comes from the results of the identification of Pteridophyta in the Sikarim Waterfall Area. The e-module presents the material in three learning activities. Learning activity I with the title getting to know ferns (Pteridophyta) as biodiversity contains material on the concept of biodiversity, levels of biodiversity, getting to know ferns (Pteridophyta) more closely, the structure and morphological characteristics of ferns (Pteridophyta), the way of life of ferns (Pteridophyta), and metagenesis of ferns (Pteridophyta). Learning activity II with the title classification of ferns (Pteridophyta) and their benefits contains material on the level of plant taxa, classification of ferns (Pteridophyta), benefits of ferns (Pteridophyta), and making dry herbariums. Learning activity III with the title diversity of ferns (Pteridophyta) in the Sikarim Waterfall Area contains material on factors that influence the growth of ferns (Pteridophyta), binomial nomenclature, description of the Sikarim Waterfall, and Pteridophyta in the Sikarim Waterfall Area.

The design of the material is based on the results of confirmation with biology teachers, so that it can be in accordance with the objectives and learning indicators used in schools. The developed e-module framework contains a cover, menu page, foreword, instructions for using the e-module, Learning Outcomes (CP) and Learning Objective Flow (ATP), concept maps, learning activities containing learning objectives, Pancasila student profiles, material descriptions, summaries, assignments and discussions, and formative tests or quizzes. The formative test contains 10 questions/quizzes and a 15-minute working time. The e-module also contains a bibliography, glossary and author identity. This is in accordance with the Directorate General of Primary and Secondary Education (2017) that the components in the e-module contain a cover, introduction, learning, evaluation, bibliography and appendices.

The e-module design was made with the help of iSpring suite 10 software. This software is integrated with Microsoft Powerpoint which makes users not need special skills and does not require much time in making it. In addition, iSpring suite10 can convert presentation files (ppt format) into flash format (swf format) which makes flash have the advantage of being so small in size but can display amazing web animations (Irhasyuarna & Yulinda, 2022). After the e-module design is completed with iSpring suite 10, it is then published in html format and can then be converted into apk format using the website 2 apk builder. The storyboard of the e-module is listed in attachment 29.

c. Develope

At the development stage, the aim is to produce a finished product in the form of an e-module on the diversity of Pteridophyta in the Sikarim Waterfall Area, adjusting the design that has been made. The resulting product is made as attractive as possible for high school students. In addition, at the development stage, a

validation test is also carried out to assess the e-module, then the results of this test are used to revise the e-module that has been developed to make it even better. Validation by experts is carried out to find out the shortcomings of the product. The e-module is validated by expert material and media expert validators, each consisting of two people consisting of an expert lecturer and a biology teacher. The results of the expert validation of the material are presented in table 5.

Tabel 1 Material Expert Validation Results

No	Aspect	Average Total Score	Presentase (%)	Interpretation
		Expert 1 Expert 2		
1.	Truth of the material	37,5	93,75%	Very worthy
2.	Compliance with learning objectives	7,5	93,75%	Very worthy
3.	Presentation of material	29,5	92,18%	Very worthy
	Average		93,22%	Very worthy

Based on the results of the validation of material experts with a percentage of 93.22% with the category "Very feasible", it was decided that the aspects of the truth of the material, suitability with learning objectives and presentation of the material in the e-module Diversity of Pteridophyta in the Sikarim Waterfall Area were very feasible to use.

Table 2 Media Expert Validation Results

No	Aspect	Average Total Score	Presentase (%)	Interpretation
		Expert 1 Expert 2		
1.	Appearance	49	87,5%	Very worthy
2.	Media efficiency	35,5	83,5%	Very worthy
3.	Instruksional	32,5	90,27%	Very worthy
	Average		87,17%	Very worthy

Based on the results of media expert validation with a percentage of 87.17% with the category "Very feasible", it was decided that the appearance, media efficiency and instructional aspects in the e-module Pteridophyta Diversity in the Sikarim Waterfall Area were very feasible to use..

d. Disseminate

The dissemination stage in this study was carried out by distributing e-modules that had been developed and revised according to the suggestions and input of experts. Limited trials were conducted in one class, namely class X-7 SMAN 1 Mojotengah with 36 students. The trial was conducted to determine the responses of students and teachers to the developed e-modules, as well as to determine the effectiveness of the developed e-modules on students' cognitive learning outcomes..

Based on the questionnaire responses given to students regarding the e-module, it received good responses. This is evidenced by the results of student

responses with a total of 36 students, the e-module based on the diversity of Pteridophyta in the Sikarim Waterfall Area on the material of biodiversity received a score of 82.22%. According to Arikunto, (2013) the teaching materials developed received a very feasible category. The feasibility of the e-module based on student responses is based on media, material, and instructional aspects. In accordance with Dina's statement (2022) which states that a positive response to a learning resource can indicate that students become more understanding, learn independently, are active, and have a high interest in the learning.

Based on the questionnaire responses given to teachers regarding the e-module, it received good responses. This is proven by the results of teacher responses, the e-module based on Pteridophyta diversity in the Sikarim Waterfall Area on the material of biodiversity received a score of 95.57%. According to Arikunto, (2013) the teaching materials developed received a very feasible category. The feasibility of the e-module based on student responses is based on media, material, and instructional aspects. The e-module is a new innovation to help teachers in delivering material based on local potential. In addition, the components contained in this e-module have met the characteristics of the module, namely self-instructional, self-contained, stand alone, adaptive, and user friendly.

The Effectiveness of the Pteridophyta Diversity E-Module in the Sikarim Waterfall Area on Students' Cognitive Learning Outcomes

The effectiveness of e-module based on Pteridophyta diversity in the Sikarim Waterfall Area on students' cognitive learning outcomes is seen from the students' pretest and posttest scores. The instrument used was multiple-choice questions with a total of 25 questions and were questions that had been selected after being tested for construct validity by expert lecturers and empirical validity (validity and reliability tests) so that they were suitable for measuring cognitive learning outcomes. The results of the N-Gain value calculation can be seen in table 4.7.

Tabel 7. *N-Gain* Score

Pretest	Posttest	N-Gain Score	Interpretation
47,33	88,78	0,789	Hight

Based on the research results, it can be seen that there is an increase in student learning outcomes as seen from the average increase between the pretest and posttest. The average pretest was 47.33 while the average posttest of students was 88.78. This shows that there is an increase in student learning outcomes before using the e-module based on Pteridophyta diversity in the Sikarim Waterfall Area and after using the e-module. The effectiveness of the developed e-module can be seen from the results of the N-gain calculation. From the results of the pretest and posttest scores for 36 students in grade X-7, the n-gain score was 0.789 or it can be said that the increase in student learning outcomes is categorized as "high". This is in accordance with Lestari & Yudhanegara (2015) that a product can be said to be effective if it has an increase in learning outcomes obtained from the pretest and

posttest scores with a minimum result in the "moderate" category or more than 0.3 from the results of the N-gain test.

The improvement of students' cognitive learning outcomes shows effective results with the use of e-modules based on Pteridophyta diversity in the Sikarim Waterfall Area on biodiversity material. Students are able to expand and gain knowledge through e-modules. The improvement in learning outcomes from before using e-modules to after using e-modules, because students' knowledge develops after learning using e-modules. This is because the e-modules are arranged in easy-to-understand language, there are pictures and videos and the appearance of the e-modules is also attractive, so that it can help students understand the material more easily. This is in accordance with the opinion of Ningsih, Miaz & Zikri (2019) who stated that digital modules have the advantage of being accessible anytime, anywhere without the need to install applications on a laptop, integrating content through video, audio, and images to help students understand learning materials.

SUMMARY

Based on the results and discussion, it can be concluded that the ferns found in the Sikarim Waterfall Area consist of 17 species belonging to 5 orders and 12 families. These types are from the Polypodiales order which includes the families Thelypteridaceae, Davalliaceae, Nephrolepidaceae, Polypodiaceae, Lindsaeaceae, Dennstaedtiaceae, Blechnaceae, and Pteridaceae; the Gleicheniales order includes the Gleicheniaceae family; the Selaginellales order includes the Selaginellaceae family; the Marattiales order includes the Marattiaceae family and the Lycopodiales order includes the Lycopodiaceae family.

Based on the validation that has been carried out, the e-module of fern diversity in the Sikarim Waterfall Area is suitable for use as teaching material in biology subjects for class X. This is based on the feasibility value obtained from media experts of 87.17%, material experts of 93.22% and the completion of response sheets from teachers of 95.57% and from students of 82.22%. The e-module of fern diversity in the Sikarim Waterfall Area is also effective for improving students' cognitive learning outcomes based on the results of the N-Gain calculation of 0.789 with high criteria.

The e-module on the diversity of ferns in the Sikarim Waterfall Area is expected to meet the needs and as a support in biology learning. It is expected that this e-module can help students in improving cognitive learning outcomes on biodiversity material based on the potential of Pteridophyta in the Sikarim Waterfall Area. In addition, this research is expected to be used as a reference for further researchers. In further research, it is expected that there will be a test of the effectiveness of the e-module in increasing learning interest, critical thinking skills, or others.

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