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Exploration of Ferns in Indrokilo Botanical Garden, Boyolali for the Development of Interactive Multimedia for High School Biology Learning

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Abstract: In today's digital era, conventional learning media has begun to be abandoned. Currently, many modern learning media have been developed such as interactive multimedia, video media, and others so that the learning process becomes fun and students are actively involved in the learning process. The purpose of this study is; to explore the diversity of ferns in the Indrokilo Boyolali Botanical Garden and develop interactive biology multimedia materials for high school. The methods used are field exploration, taxonomic identification, and development of interactive multimedia. The research location is at the Indrokilo Boyolali Botanical Garden and the research was conducted for 3 months starting from December 2022 to February 2023. The results of the research and identification at the Indrokilo Botanical Garden found 31 types of ferns from 14 families and 3 classes. The interactive multimedia developed combines text, images, animations, and interactive videos. This multimedia has been evaluated and received positive validation results, so it can be used as interactive media in high school. Interactive media with other plant samples still needs to be developed because the Indrakilo Botanical Garden is a source of plant diversity.

Keywords: Exploration; Ferns; Indrokilo Botanical Garden; Interactive multimedia

Introduction

Indrokilo Botanical Garden is located in Kemiri sub-district, Mojosongo sub-district, Boyolali district. Indrokilo Botanical Garden Boyolali has an area of 8.9 hectares and is one of the nature conservation areas rich in biodiversity, with a diverse collection of plants, such as medicinal plants, fruit plants, ornamental plants, etc. The number of plant collections reaches 368 species. In addition, there are 7 iconic places/buildings that are also interesting to explore, namely the labyrinth garden, nail garden, kolan painting feature, and ecological house. (Disporapar Central Java Province. 2024; Budiharto at al. 2020).

Technology is an innovation that has now become commonplace because at this time it has entered the world of the digital era 4.0. Technology is a meanScience and technology are continuously developing and have caused many changes in all areas of life, including developments in the world of education (Widiasanti et al., 2023; Yulia et al., 2023) of activity and facilitates the process. Currently, technology has also entered the field of education. The role of educational technology can also be used as a medium for delivering learning messages to students, in all subjects at school, of course, the role of technology is very helpful for teachers in developing learning methods that are in accordance with the characteristics of 21st-century students, the use of educational technology also provides opportunities for teachers and students to innovate and be creative in the teaching and learning atmosphere in the classroom (Hadiyastama et al., 2022). This helps the students to strengthen self-esteem and develop high level thinking skills in a learning community (Suh, 2011).

The use of technology in the field of education, especially in the teaching and learning process, has been proven to increase students' interest in learning because it provides a new and interesting learning experience so

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that students will avoid feeling bored during learning. Learning technology media helps to solidify knowledge in the minds of students and bring lessons to life which can facilitate students' understanding (Hadiyastama et al., 2022) The development of science and technology in the field of education makes educators able to always be creative, including in the use of media (Henriksen et al., 2016) One of the media that is growing rapidly in line with the development of science and technology is an interactive multimedia (Dalle et al., 2017), and Interactive multimedia is a learning medium that uses computers in the application process. Interactive multimedia can be accessed easily on the internet and can be used offline or online (Yulianci, at al. 2021).

The use of technology in the field of education is integrated with a learning sub-system, namely as one of the facilities that can be utilised by educators or students who can benefit from the use of learning media. Ayu and Manuaba (2021) also stated that teachers need interesting learning media in the process of learning and teaching activities. The development of learning activities needs to be carried out, one of which is by developing the learning media used, that Media is a facilities that should be utilized maximally due to develop the student's motivation in learning (Dewi, 2019; Guan, et al., 2018; Alemdag and Cagiltay, 2018). Learning media that supports the absorption of a lot of information is one of the needs that can play a role in providing the effectiveness of learning activities (Putra, and Salsabila, 2021).

Biology education in high school plays an important role in equipping students with scientific knowledge and skills about living things. One of the important materials in biology is ferns, which have significant species diversity and ecological roles. Indrokilo Botanical Garden, Boyolali, Central Java, is one of the locations rich in fern diversity (Disporapar Provinsi Jawa Tengah. 2024).

Indrokilo Botanical Garden, Boyolali, Central Java, is home to a diverse collection of ferns, but its potential in education is still not fully explored. It is necessary to develop interactive multimedia for learning resources from research results at the Indrokilo Botanical Garden. Interactive multimedia, which is a combination of text, images, animation, sound, and video, requires the involvement of many senses in the learning process. The involvement of various senses in the learning process can make it easier for students to gain knowledge and a new atmosphere in learning (Wiana, 2018). The more senses involved, the more knowledge is gained (Robbia, A & Fuadi, H. 2020) With an attractive appearance, the boredom experienced by students due to monotonous learning can be reduced, so that students are more interested in understanding the material given (Novitasari, 2016).

In the digital era and the increasing challenges of distance learning, multimedia has become a very important tool in bringing an engaging and effective learning experience. In particular, in the context of learning biology at the senior high school level, the use of multimedia can enrich students' understanding of biodiversity. Indrokilo Botanical Garden can be an inspiration to develop interactive media for Biology learning in Senior High School. The objectives of this research are: 1. Identify and document the diversity of fern species in the Indrokilo Botanical Garden. 2. Designing and developing effective and interesting high school biology learning multimedia based on the diversity of ferns in the Indrokilo Botanical Garden. With the hope that the interactive multimedia produced will benefit the world of education and improve the quality of Biology learning, especially in high school.

Method

Time and Place

The research was conducted for 3 months. Data collection of fern diversity was carried out in the Indrokilo Botanical Garden, Boyolali, on Sunday 3 December 2022. The data analysis and development of interactive multimedia learning in the Biology Laboratory of the University of Veteran Bangun Nusantara in January 2023 and Senior High School of Veteran Sukoharjo partner school for implementation and evaluation of multimedia learning in February 2023.

Activity Stages

This research uses the Research and Development (R&D) model which consists of several stages: Research and Development: a. Conducting exploration and inventory of ferns in Indrokilo Botanical Garden, Boyolali. b. Identifying and classifying the fern species found. c. Developing biology multimedia learning materials. d. Designing and developing biology learning multimedia. Designing and developing biology multimedia learning, for multimedia trials (Rahmat, and Arnawa, 2019), three stages were carried out, including;

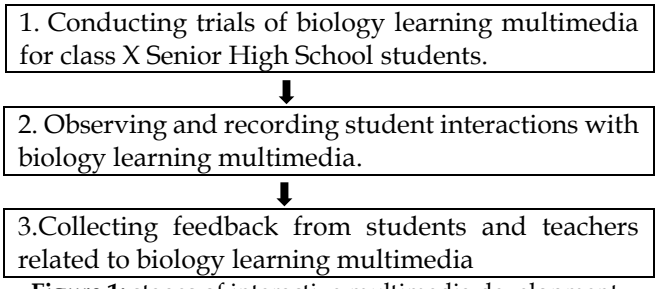


Figure 1: stages of interactive multimedia development

Analysis and Revision, Data analysis in this study is descriptive qualitative and quantitative. Qualitative descriptive analysis to analyse the acquisition of data on criticism and suggestions given by validators, which are then used as a basis for improvement. While quantitative descriptive analysis techniques describe the acquisition of scores based on validation questionnaires. Quantitative data analysis through the following stages. a) Convert the assessment score following the provisions (Sugiyono, 2015) as in the following Table 1.

Table 1. Scoring guidelines

Assessment	Score
very good	5
both	4
Simply	3
less	2
very less	1

Determining the percentage value, the percentage of media validation from experts, teachers, and students can be calculated using the following formula (Sugiyono, 2015). Biology learning multimedia of High school: ICT-based learning media designed to help students learn high school biology material, especially about ferns, which consists of material content, structure, format, visual design, and interactivity.

Converting the percentage value, the values that have been obtained are then grouped based on the criteria for the validity of the research data. The media is declared feasible if the percentage level reaches 62 - 81%. The previous data in the form of numbers was then converted into five-scale qualitative data. The following Table 4 is a guideline for converting data.

Table 2. Score conversion guidelines

Achievement Level (%)	Qualification	Description
80 - 100	Very Valid	Very good, not revised
60 -79	Valid	Appropriate, no need to revise
40 - 59	Fairly Valid	Not suitable, needs revision
20 - 39	Less valid	Not suitable, needs revision
< 20	Very Poorly Valid	Very inappropriate, and needs revision

Source: (Sugiyono, 2015)

Scope or Object

The scope of this research includes: a. Ferns in Indrokilo Botanical Garden: Types of ferns, and their morphological characteristics. b. High school biology learning multimedia: Material content, structure, format, visual design, and interactivity.

Result and Discussion

Research Results

The results of the exploration of ferns in Indrokilo Botanical Garden Boyolali which found 31 interesting and informative findings. This discovery provides a fairly comprehensive picture of the diversity of ferns in the location. The results can be seen in Table 3.

Table 3. Identification Results of Ferns in Indrokilo Botanical Garden

Ordo	Family	Genus	Spesies
Polipodyales	Pteridaceae	Pteris	Pteris biaurita
			Pteris tripartita
			Pteris vittata
		Adiantum	Adiantum pedatum
			Adiantum tenerum
			Adiantum trapeziforme
		pityrogramma	Pityrogramma calomelanoss
	Polipodiaceae	Pyrrosia	Pyrrosia piloselloides
			Pyrrosia longifolia
		Drynaria	Drynaria sparsisora
		Phymatosorus	Phymatosorus scolopendria
		Microsorum	Microsorum punctatum
		Platycerium	Platycerium bifurcatum
	Dryopteridaceae	Nephrolepis	Nephrolepis cordifolia
			Nephrolepis hirsutula
			Nephrolepis falcate
		Pleocnemia	Pleocnemia sp
	Thelypteridaceae	Sphaerostephanos	Sphaerostephanos sp
	Dennstaedtiaceae	Microlepia	Microlepia strigose
		Hypolepis	Hypolepis teneuifolia
	Woodsiaceae	Diplaziu	Diplazium esculentum
	Aspleniaceae	Asplenium	Asplenium nidus
Marattiales	Marattiaceae	Angiopteris	Angiopteris evecta

Ordo	Family	Genus	Spesies
Selaginellaeles	Selaginellaceae	Selaginella	Selaginella plana
Filicales	Thelypteridaceae	Christella	Christella arida
			Chistella parasitica
Cyatheales	Cyatheaceae	Cyathea	Cyateha contaminas
	Dicksoniaceae	Cibotium	Cibotium baromets
Schiales	Lygodiaceae	Lygodium	Lygodium lomgifolium
Ophioglossales	Ophiolossaceae	Helminthostachys	Helminthostachys zeylanica
Equisetales	Equisetinaceae	Equisetum	Equisetum debile

As multimedia-mediated content is incorporated into the learning environment, theinformation-rich presentations make the learning instructions more effectively than presenting through a singlemedium in rote learning, so the students can obtain the information more meaningfully and repeatedly throughdifferent media and choices (Dembo & Seli, 2012) The interactive multimedia developed includes learning objectives, Student Worksheets, practice questions, and online-based evaluations, especially in the context of learning about the diversity of ferns in high schools. From the results of the validation of media experts, material experts and students, there are several corrections. The results of the validation of the multimedia that has been developed are as follows, in the Table 4.

Table 4. Multimedia Validation Results

Validator	Validationresults (%)	Conclusion
Material Expert (lecturer)	94	Highly Valid, the materials presented are relevant, accurate, appropriate to the standards and learning objectives
Media Expert (lecturer)	81.3	Very Valid, the technical and presentation aspects of media are rated quite good.
High school biology teacher	92	Very Valid, interactive media is following the curriculum and learning in the classroom
High school students	91.3	Very Valid, interactive media is interesting and useful for students

Discussion

The types of ferns found

Indrokilo Botanical Garden Boyolali is a habitat rich in fern diversity. This is following the Indrokilo Botanical Garden programme that ferns are one of the thematic parks of 8 other thematic parks. (Khasanah, 2023). This diversity needs to be developed again when compared to previous research at the Cibodas Botanical Garden has a collection of ferns of approximately 101 species (Jasin and Tatang, 2022).

With the findings of 31 species from 12 families, we can see that the botanical garden provides favourable environmental conditions for the growth and development of a wide range of ferns. This is consistent with the common knowledge that ferns usually dominate in moist and shady environments, such as those usually found in botanical gardens. (Kayu, RB et.al. 2019) and (Janna, M., Riastuti, R. D., & Sepriyaningsih. 2020).

In addition, it is interesting to note that of the 4 fern classes, only the Psilophyta class was not found in this exploration. Nonetheless, this shows that the Psilophyta class is known to be a relatively small and less common group compared to other classes such as Polypodiopsida, Lycopodiopsida, and Equisetopsida.

The class *Psilophyta*, are ancient and extinct ferns. Most of the fossilised ancient ferns were found living in the Devonian period with extinction expected due to very high tectonic activity at the time. However, there are still ancient fern species that have survived to the present day such as *Psilotum nudum* and *Psilotum complanatum* which is the Psilotum genus. *Psilotum nudum* has existed since 400 million years ago and its existence is now included in the critical level, so Psilotum is not available even though the environment is very favourable for the growth of this type of fern.

Ferns are most commonly found on the inside and around the dome, which is a thematic place for ferns. In general, ferns are distributed throughout the botanical garden, attached as epiphytes to trees and walls, and live terrestrially on flat ground, ditches, and pond edges. The presence of domes as thematic sites for ferns suggests that the microhabitats in and around the domes provide optimal conditions for fern growth and development. Factors such as humidity, light, and airflow within the dome are likely to favour the preservation of ferns.

The most dominant ferns are the Pteridaceae family and the Polypodiaceae family. The Pteridaceae family consists of 3 genera, namely 1) Pteris, including Pteris tripartita, Pteris biaurita, and Pteris vitata; 2) Adiantum includes Adiantum tenerum, Adiantum pedatum, and Adiantum trapizeforme; and 3) the genus Pityrogramma. As for the Polypodiaceae family, there are 5 genera with 1 species each including Drynaria sparsisora, Microsorum punctatum, Phymatosorus

scolopendria, Platycerium bifurcatum, and Pyrrosia longifolia.

The number of species from the Pteridaceae and Polypodiaceae families is influenced by environmental conditions and resilience. Pteris is classified as a cosmopolitan fern species that can live in a variety of habitats (Hutasuhut, M. A., & Febrian, H. (2019). The species in this genus can live in humid places with low and high elevations, both in the open and shaded by sunlight. Similar to Pteris, Adiantum also can survive in hot and dry conditions even though it likes moisture (Heim 2015). Ferns develop well when the abiotic environment is favourable, especially humidity. Based on the measurement of temperature and humidity in the sampling area, the results were 64% and 30^{o} C, respectively. While the soil pH, based on measurements obtained a result of 5 or classified as acidic. The measurement results of abiotic parameters show that the environment is ideal for the growth of ferns. The percentage degree of humidity suitable for the growth of ferns is in the range of 60-90% with an ideal temperature of 27-29^{o} C (Janna et al., 2020).

Interactive Multimedia Development

The development of interactive multimedia includes learning objectives, Student Worksheets, materials, practice questions, and online evaluation in the development of biology education, especially in the context of learning about fern diversity in high school.

The development of comprehensive interactive multimedia for biology learning, as described in this study, is a very positive step in improving the quality of biology education in high school. This interactive multimedia has several advantages over traditional learning methods, among others: (1) Increase student motivation and interest: Interactive multimedia can attract students' attention and make them more involved in the teaching and learning process. This can increase students' motivation and interest in learning biology material, especially about fern diversity; (2) Improve student understanding: Interactive multimedia can present information in various formats, such as text, images, videos, and animations. This can help students to understand the material more easily and deeply; (3) Improve students' critical thinking skills: Interactive multimedia can provide students with opportunities to practice critical thinking skills, such as analysing data, solving problems, and making inferences; (4) Increases student independence: Interactive multimedia allows students to learn independently at their own pace. This can help students to develop independence in learning (Ali, M. & Aslam, 2010) and (Mayer, R.E., 2009).

The provision of clear learning objectives in interactive multimedia will help direct students towards achieving the desired learning outcomes. This is to the principles of effective learning, where specific and measurable learning objectives can increase student motivation and learning focus. (Wijarini, et al., 2014)

Furthermore, the presence of worksheets in interactive multimedia will provide opportunities for students to interact directly with learning materials. The worksheets can be designed to support active and collaborative learning, which effectively improves understanding and retention of subject matter (Yuliance et al., 2017)

The materials presented in interactive multimedia can be adjusted to the curriculum and learning standards of high school biology, and supported by relevant and up-to-date content. References to credible reference sources, such as textbooks or scientific journals, can enrich learning materials and increase the accuracy of information conveyed to students. (Makaborang, 2019) (Sanaky, 2013).

In addition, the practice questions included in the interactive multimedia will allow students to test their understanding of the learning material. Practice questions can be designed with a variety of difficulty levels and question styles, thus accommodating students' different needs and learning styles. Online evaluation, such as using the Quizizz platform, can provide instant and thorough feedback on students' understanding of the learning material. In addition, online evaluation can also help identify areas for improvement in learning and provide valuable data for teachers to adjust their teaching approach (Wiliam, D., 2016).

The material expert's validation of 94% indicates that the content and materials presented in the interactive media are considered relevant, accurate, and in line with biology learning standards and objectives. This is consistent with the principles of effective learning, where quality content that meets the needs of users is a key factor in the success of learning media. (Harahap, M., & Siregar, L. M., 2018). One of the suggestions given is the need for the addition of special instructions in multimedia. This shows the importance of providing clear directions to users on how to use multimedia and make the most of the features provided. Instructional design and creation of interactive multimedia materials, where it is recommended to pay attention to user needs and provide clear and easy-to-understand instructions (Rahmat, Stephanus Turibius. 2015).

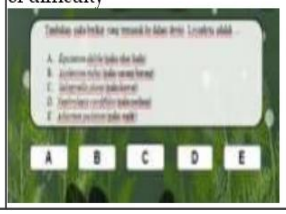
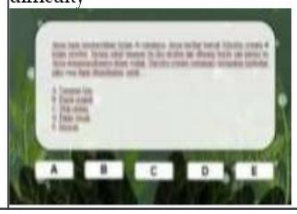
No	Suggestions	Revision
1.	The text size on some slides is too small 	Improvements were made by increasing the font size 
2.	Problems are still at a low level, mohom is made to a higher level of difficulty 	Improvements were made to the questions, by increasing the level of difficulty 

Figure 2: Images of Validator Feedback

No	Suggestions	Revision
3.	The background color is brightened to contrast with the color of the letters and writing. Please complete the classification 	Improvements were made by changing the background color so that the writing was clearer and more complete in the classification section 
4.	There are no special instructions available in the question section 	Improvements were made by adding special instructions to the questions 

Figure 3: Images of Validator Feedback

Feedback on colour contrast, incomplete classification, and insufficient font size provide insights into the importance of good visual design aspects in the creation of learning multimedia. The literature on graphic design and information visualisation can guide the effective use of colour, layout and font size in improving the readability and accessibility of learning multimedia.

From the material experts' feedback, we can better develop instructional design, learning evaluation, and graphic design. Thus, these findings not only provide valuable feedback for multimedia development but also enrich our understanding of effective multimedia design principles in supporting biology learning. (Rahmat, Stephanus Turibius. 2015)

The media expert's validation of 81.3% indicated that the technical and presentation aspects of the interactive media were also rated as excellent. This includes clarity of layout, intuitive navigation, and adequate visual quality. References to the principles of multimedia design and interactive application development can provide useful insights into understanding the factors that influence validation from media experts. (Hasanah, N. F., 2020).

Validation from biology teachers at 92.0% indicates that the interactive media is considered to be in line with the curriculum and fulfils learning needs in the classroom. This suggests that interactive media can be well integrated with biology teaching in schools and help support the achievement of learning objectives. (Harahap, M., & Siregar, L. M., 2018).

The student validation of 91.3% shows that interactive media is considered interesting and useful in their learning. This suggests that interactive media can motivate and engage students in their learning process, which is an important factor in successful learning. (Roosita, B., Lestari, D. P., Setyawan, A., 2022)

The overall validation results show that the interactive media developed has passed a strong validation process from various parties involved, including material experts, media experts, biology teachers, and students. The high percentage of validation results indicates that this media is overall considered feasible to use by all parties involved in the validation process.

Based on the research results of Rahmatsyah, Sy and Dwiningsih, K. 2021, it can be concluded that the interactive e-module developed by referring to the 4D research model (Define, Design, Develop, and Disseminate), is said to be very feasible in terms of validity scores with each obtaining a score of 90% for content criteria, 93% for presentation criteria, 84% for language criteria, and 100% for graphic criteria. This interactive e-module is very practical to use, this is evidenced by the results of student responses, each criterion gets a score of >81% which can be categorized as very responsive.

The results (Sianturi, A and Retnoningsih.A. 2021) of the interactive e-book validation by material experts were declared feasible and media experts declared very feasible. Small-scale trials involving 20 students on interactive e-book readability also included positive criteria. Finally, the application of interactive e-book on nail plant material on a large scale has also proven effective as a teaching material so that it can be used as an alternative learning resource. This inactive e-book will make it easier for students to understand

the concept of ferns because of the completeness of the picture and its suitability with the ferns in the students' environment in interactive media plant identification includes a demonstration of how to use a dichotomous key; this requires knowledge of various botanical terms and can be challenging, confusing, and frustrating for students. Here, we develop a multimedia tool to help students (1) learn botanical terms, (2) practice, train, and test their knowledge of plant identification, and (3) self-evaluate their level of learning.

Utilization of multimedia facilities and internet media can be an effective learning tool. Through the use of multimedia technology and internet media, it provides high accessibility and flexibility for students, increases students' understanding of learning material, accelerates learning efficiency, and provides a more interesting and interactive learning experience. Several other advantages of using multimedia and internet media in learning are expanding access to information, facilitating collaboration between students and teachers, and enabling flexible distance learning (Widiasanti at al., 2023). Research conducted (Aswirna & Ritonga, 2020; and Dewi & Agung, 2021) shows that the use of e-books can improve student learning outcomes in history subjects. In this study, e-books are used as learning media which contain historical materials that are presented interactively. The results of this study indicate that students who use e-books in learning have better learning outcomes compared to students who do not use e-books.

In the preparation of interactive multimedia, it is necessary to pay attention to the content of motivation, attitudes, encouraging involvement, so that it really improves learning outcomes. This factor emphasizes the need for a holistic approach to the design and implementation of interactive multimedia where student experience is the main consideration. Challenges of problems, such as problems related to Internet connectivity, device accessibility, and student familiarity with e-learning technology also need to be considered in order to create a conducive e-learning environment with interactive multimedia. (Erandika, at al. 2024).

For multimedia developers, (Grabinger's (1993) suggestion in Stemler, 2007) states that there are three basic problems that designers can try to improve: (a) attracting students' attention, (b) helping students find and organize relevant information, and (c) integrating the information into the student's knowledge structure. Rather than focusing on text elements, graphics, and audio visuals to create a screen that is organized, structured, and visually appealing.

Conclusion

From the research results in the Indrokilo Botanical Garden, 31 species of ferns have been found consisting of 14 families in 3 classes. From the results of the identification of ferns, interactive multimedia has been developed that combines text, images, animations, and interactive videos, so that it can be used as an interesting learning resource. This multimedia has been evaluated and received positive validation results, so that it can be used as interactive media in high school. Interactive media with other plant samples still needs to be developed because the Indrakilo Botanical Garden is a source of plant diversity.

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Author Contribution
Conceptualisation, AP and NRH; methodology, S; data collection and analysis, AP and NRH; literature sourcing, AP and NRH; writing-drafting article, NRH; writing-reviewing and editing, AP and S: final visualisation. AP and NRH; language translation. All authors have read and approved the published version of the manuscript. Funding There is no external funding. Conflict of Interest No conflict of interest

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