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Development of a mind map-based module to improve student learning outcomes in ecosystem biology learning material

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Abstract

Students still need help understanding biology subject matter, one of which is the concept of biological ecosystems, due to limited variations in learning media. Mind maps are considered to affect students' mentality and learning outcomes positively. This research aims to develop a mind map-based module to improve student learning outcomes in biology learning that is valid, practical and effective in ecosystem material. This research is research and development (R&D) that uses the 4D model. This research was conducted at SMA Dharma Utama Serdang Bedagai, Medan, for the 2022/2023 academic year. Data was collected using validation sheets, student questionnaires and test instruments. Next, the data is compiled using the N-gain formula. This product was declared valid by media validators (68%) and material (80%). The feasibility analysis results show that the product developed is very practical for students to use, with the N-gain results getting a score of 0.8 in the very high category. Based on this mind map module, student learning outcomes using the mind map module developed are valid, practical and effective in facilitating student learning outcomes using the mind map module with ecosystem material.

Abstrak. *Peserta didik masih mengalami kesulitan memahami materi pelajaran biologi, salah satunya pada konsep ekosistem biologi, karena keterbatasan variasi media belajar. Mind map dinilai berpengaruh positif terhadap mental dan hasil belajar peserta didik. Penelitian ini bertujuan untuk mengembangkan modul berbasis mind map untuk meningkatkan hasil belajar siswa dalam pembelajaran biologi yang valid, praktis dan efektif dalam materi ekosistem. penelitian ini adalah penelitian dan pengembangan (R&D) yang menggunakan model 4D. penelitian ini dilakukan di SMA Dharma Utama Serdang Bedagai, Medan untuk tahun akademik 2022/2023. Data dikumpulkan menggunakan lembar validasi, angket siswa dan instrument tes. Selanjutkan data dikumpulkan menggunakan rumus N-gain. Produk ini di nyatakan valid oleh validator media (68%) dam materi (80%). Hasil analisis kelayakan menunjukkan bahwa produk yang dikembangkan sangat praktis digunakan siswa dengan hasil N-gain mendapatkan nilai 0,8 dengan kategori sangat tinggi. Berdasarkan modul mind map ini dapat disimpulkan bahwa hasil belajar siswa menggunakan modul mind map yang dikembangkan valid, praktis dan efektif untuk memfasilitasi hasil belajar siswa menggunakan modul mind map dengan materi ekosistem.*

A. Introduction

Biology is one of the courses that pushes students to develop their conceptual understanding and knowledge construction (Tanjung et al., 2022). However, because biology involves so many interconnected concepts, students sometimes struggle to understand the subject, making learning challenging (Rahmi et al., 2023). Low student learning outcomes will stem from their inability to comprehend the course information. Failure to meet learning objectives can be attributed to expected student learning outcomes (Azizah & Alberida, 2021). Media, equipment, and teaching strategies employed by teachers that do not meet the needs of their students can also contribute to low biology learning results (Mahmuda, 2018).

The presentation of the subject in the form of essays, which nevertheless contain a lot of writing, is one of the drawbacks of learning textbooks, workbooks, and modules, according to conclusions drawn from observations and interviews with subject matter experts in biology using student worksheets, books, and modules. As a result, students become less independent and have a more challenging time understanding the content they are studying. Students' inability to understand the material leads to low learning outcomes.

This calls for instructional resources, such as modules, that may make learning materials simple for students to understand and help them develop into internal, autonomous learners. A module is a teaching resource that takes the shape of an independent package book and is filled with a sequence of lessons that are methodically organized to help students become self-sufficient learners (Ginting et al., 2020). Because modules are designed to feature eye-catching graphics, current information about the subject, questions, and other activities that will eventually improve student learning outcomes, they are also thought to help overcome students' indifference to studying (Suhardi, 2018). To reach the best results, using modules can also increase the efficacy and efficiency of school instruction in terms of time, money, resources, and energy. Learning using modules is one kind of tailored instruction that may be used in the classroom since it allows students to set their learning objectives and pace for content mastery (Martiningsih et al., 2019).

Nevertheless, there are still specific issues with some of the produced modules. These include the presentation of repetitive information, a compilation of topics with a generic discussion that isn't tailored to the specifics of each subject, and a ton of practice questions. Moreover, given that it mainly consists of assignments and theory, it appears somewhat dull. As a result, the researcher wants to create an autonomous and not only theoretical module; one way to do this is by integrating mind maps. This module was designed to satisfy the demands of students for learning materials with more straightforward, comprehensible, and engaging content (Orkha et al., 2020).

A mind map is a creative, helpful note-taking method that maps students' ideas as they comprehend a subject by combining images, symbols, colours, letters, and words related to each other as an explanation (Abdullah et al., 2022). This method has the advantage of balancing the functions of the right and left brains, which helps students retain their knowledge for longer. The goal of the mind map learning approach is to maximize each student's potential, which will help them develop a positive self-concept that promotes both learning objectives and mental health (Rahman, 2018).

The creation of mind map-based modules has been the subject of numerous studies. This research combines R&D by Borg and Gall, which has ten stages in its development, to construct mind map-based modules with a project-based learning (PJBL) model that focuses on boosting student accomplishment (Yunita & Untari, 2018) and creating an educational module with a Science, Technology, and Society (STS) theme with mind maps. This study takes advantage of Borg and Gall's R&D on materials that cause environmental damage (Listiani & Prasasti, 2021). Other research also created a mind map-based biology module utilizing content related to the digestive system with R&D (Selaturrohmi & Haikal, 2024). It is envisaged that using mind map-based modules in biology education will result in more engaging, interactive, and fascinating biology instruction.

B. Material and Method

Participants

This study only included one biology teacher and eighteen students from class X at IPA SMA Dharma Utama Serdang Bedagai Medan North Sumatra. This study included tests, questionnaires, observations, and interviews as sample methods. There are three procedures in the process of selecting research subjects: (1) picking a specific area, (2) picking a nearby school to serve as the research site, and (3) selecting a class from among those that are accessible for use as research subjects. Purposive sampling was used because it was easier to collect research data according to the deliberate selection of areas, schools and classes. According to Aryawiantar et al. (2015), purposive sampling provides a foundation for creating learning gadgets in the 4-D development paradigm.

Research Design and Procedures

The 4D model is utilized in this research because it may serve as a foundation for developing learning devices with a detailed description, the processes are

organized methodically, and the research procedure doesn't take much time. By focusing on validity and practicality, this development also creates a mind map-based teaching module based on high-quality ecosystem material (Sugiyono, 2019).

Mind maps were created using the Canva app. This study protocol follows Thiagarajan's (1974) model. The four steps of the 4D development model are as follows: (2) Design: this stage aims to prepare developed products as learning devices by choosing the module format and material, then formulating indicators and learning objectives, and finally connecting the material with character education in the module. (1) Define that this stage contains activities in the form of an initial analysis of the identification of various needs and problems that exist in schools. (3) Develop (development): The objective here is to create a product that has been conceptualized and then tested by media specialists, content specialists, and character education specialists to ascertain its degree of validity (4) Disseminate stage, which involves distributing the updated and validated product results to assess their viability and practicality before evaluating how well they enhance student learning outcomes. In teaching and learning, the product is distributed following revision and the determination of validity outcomes (Arywiantari et al., 2015).

Instruments

Media expert validation sheets, materials, questionnaires, and other tools are used to gauge validity. Pre-test and post-test questions were utilized to gauge efficacy, while teacher and student response instruments were employed to gauge practicality.

Data collection and analysis technique

Formula 1 was used to determine the validity data %, which was then examined for categorization in accordance with Table 1. After calculating the percentage using practicality data, Table 2's category was examined. Additionally, effectiveness data computed the N-gain using Hake's (1998) Formula 2, after which the categorization was examined in accordance with Table 3. Additionally, the effectiveness % was computed and the categorization was examined in accordance with Table 4.

$$\text{Percentage} = \frac{\text{Score obtained}}{\text{Maximum score}} \times 100\% \ldots\ldots \text{Formula 1}$$

$$(g) = \frac{\text{Sft II} - \text{Sft I}}{\text{Smax Ideal} - \text{Sft I}} \ldots\ldots\ldots\ldots \text{Formula 2}$$

Information:
(g) = Gain score
Sft = Score of final test
Smax = Maximum score

Table 1 Validity assessment criteria

Average Score Percentage (%)	Criteria
76-100	Very Valid
51-75	Fairly valid
26-50	Less Valid
0-25	Invalid

(Source: Kristianti & Julia, 2017)

Table 2 Practicality assessment criteria

Average Percentage Score (%)	Category
76-100	Very Practical
51-75	Practical
26-50	Less Practical
0-25	Impractical

(Source: Setyaningsih & Mukodimah, 2022)

Table 3 N-gain criteria

N-gain	Category
$g > 0{,}7$	High
$0{,}3 < g \leq 0{,}7$	Medium
$g < 0{,}3$	Low

(Source: Hake, 1999)

C. Results and Discussion

In order to identify the issues facing schools, as well as the media that teachers use to impart knowledge and the extent to which students comprehend what they learn from it, the Define stage involves conducting interviews with teachers and students at Dharma Utama Private High School in Serdang Bedagai.

Figure 1 Mind map-based module cover

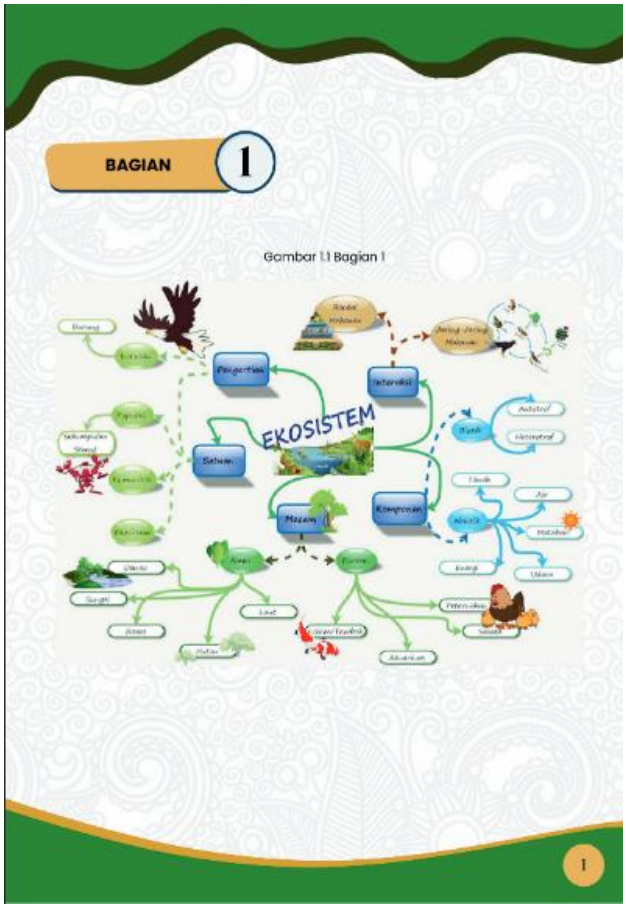

Figure 2 Mind map of biology ecosystem

The planning of the media to be used, including mind map-based module development, general learning objectives (achieving core competence and basic competence) and specific objectives (improving learning outcomes), module format selection based on existing module reviews, and Ecosystem material selection, are all part of the design stage. Content that is mind map-based will be assembled into the module, creating a high school teaching resource that is mind map-based. The mind map-based module cover can be seen in Figure 1, and the mind map example can be seen in Figure 2.

Validity of Mind Map-based Module Biology Ecosystem Learning Material

The Develop stage involves creating modules used as instructional materials for research and validating them to determine whether or not the media created by researchers is appropriate. The validation test aimed to assess the validity of the instructional materials the researchers were developing. Four validators—media validators, material validators, question instrument validators, and questionnaire instruments—performed the validation test.

Ms. Naimatussyifa Daulay, M.Pd, is a validated media expert. Table 5 displays the "Very Valid" category based on the total average validation scores received. Dr Mhd Rafi'I Ma'arif Tarigan M.Pd. validated the questionnaires, material experts, and tools. Table 6 displays the "Fairly Valid" category based on the average validation results from material experts; Table 7 shows the "Very Valid" category based on the instrument; and the questionnaire displays the "Very Valid" category based on the results. Table 8 displays the findings of the questionnaire validators' validation.

The research conducted by Syaitika & Fauziah (2023) also demonstrated the validity of the created mind map. Mind maps for biology education are available if they satisfy the minimum requirements. However, the mind map used in this study was created using PowerPoint. Solehuddin's (2022) research yielded similar results in different sorts of development. He built a Mind map using Kvisoft Flipbook.

Furthermore, Ananda et al. (2024), who created a mind map based on handouts, also saw comparable validation outcomes. These studies' findings indicate that, on average, mind map-based development satisfies the validity requirements. This demonstrates how mind maps can be used in conjunction with a variety of media and educational resources.

Practicality of Mind Map-based Module Biology Ecosystem Learning Material

The next step is to conduct a practicality test of the developed and intended mind map-based module by asking teachers and students to respond to a questionnaire about using mind map-based modules as media or instructional materials. This is done after the module has been validated.

The Dharma Utama Private High School Serdang Bedagai instructor, Mr. Tarman S.Pd, was the one who received this questionnaire. Table 9 displays the biology teachers' mind map-based module response outcomes. The biology instructor's response to the teacher response questionnaire is shown in the table above. The mind map-based module received a maximum score of 85 with a percentage of 100%, making it eligible to be classified as Very Practical.

Following that, eighteen students completed the student response questionnaire for the mind map-based module's practical test, which will be utilized in the research. Table 10 displays the replies from the 18 participants. The findings of the student reply above demonstrate that 18 students who took part in the mind map-based module received a total score of 204 out of a possible 216, or a 90% percentage result, in the very practical category. Therefore, the mind map-based module is deemed to be particularly useful for use in educational activities.

Table 5 Validation results by the media validator

Aspect	Score obtained	Maximum Score	Percentage	Category
Cover size	7	8	95%	Very Valid
Cover design	23	32	80%	Very Valid
Content design	56	68	80%	Very Valid
Score obtained		**86**		
Maximum Score		**100**		
Percentage		**86%**		
Category		**Very Valid**		

Table 6 Validation results by the material validator

Aspect	Score obtained	Maximum Score	Percentage	Category
Content Eligibility	28	16	85%	Very Valid
Language	3	3	100%	Very Valid
Visualization	8	8	100%	Very Valid
Question	3	3	100%	Very Valid
Module Compatibility With Mind map	4	4	100%	Very Valid
Score obtained		**80**		
Maximum Score		**100**		
Percentage		**80%**		
Category		**Very Valid**		

Table 7 Validation of instrument

Aspect	Score obtained	Maximum Score	Percentage	Category
Clarity	12	12	100%	Very Valid
Core precision	3	3	95%	Very Valid
Relevant	3	3	95%	Very Valid
Content validity	3	3	95%	Very Valid
No biases	8	8	100%	Very Valid
Language	12	12	100%	Very Valid
Maximum Score		**41**		
Percentage		**90%**		
Category		**Very Valid**		

Table 8 Validation results by the questionnaire validator

Aspect	Score obtained	Maximum Score	Percentage	Category
Clarity	12	12	95%	Very Valid
Core precision	3	3	95%	Very Valid
Relevant	10	6	95%	Very Valid
Content validity	4	4	100%	Very Valid
No biases	8	8	100%	Very Valid
Score obtained				
Maximum Score		**70**		
Percentage		**95%**		
Category		**Very Valid**		

Table 9 The results of biology teachers

Aspect	Score obtained	Maximum Score	Percentage	Category
Material	20	20	100%	Very Practical
Language	15	15	100%	Very Practical
Presentation	50	50	100%	Very Practical
Score obtained		**85**		
Maximum Score		**85**		
Percentage		**100%**		
Category		**Very Practical**		

Table 10 The results of biology students

Students Number	Total score	Average	Percentage (%)	Category
18	204	67 ,99	95%	Very Practical

Table 11 Results of the effectiveness of student learning outcomes

N	Pre-test	Post-test	N-gain	Category
18	54,63	95,65	0.84	High

Effectiveness of Mind Map-based Module Biology Ecosystem Learning Material

Giving mind map-based modules to students and observing the impact of those modules is how the dissemination step is carried out. Additionally, the efficacy of mind map-based modules was evaluated through direct student trials at Serdang Bedagai's Dharma Utama Private High School. Results for effectiveness are displayed in Table 11. N-gain test results indicate that the N-gain Score falls into the high range at 0.84. The average pre-test score achieved in this study was 54.63, and the average post-test score was 95.65. These data indicate a 41.0 increase in value from the pre-test value to the post-test value.

Mind map-based learning modules can help students become more motivated, curious, and enthusiastic (Sugiyanto, 2019). Positive research findings indicate that this mind map-based module development approach can be well-received by students during the learning process.

Previous studies have also shown a positive trend in developing modules or mind maps, both their practicality in application and their effectiveness on student learning outcomes. Hendra et al. (2022) found the practicality of applying green school-based modules to students' science skills in their research. Many students agreed that the developed module was easy to use in learning. Anfa et al. (2023) examined the effect of applying modules with a free inquiry learning model, finding that the modules applied positively affected students' critical thinking skills. Herditiya et al. (2023) also developed a module but in the form of a virtual practicum based on local potential, where an increase in student learning outcomes was found with a high N-gain category. The results of this study made it easier to carry out practicum, which was initially hampered during the COVID-19 pandemic.

In addition to the positive trend of the module above, Saili et al. (2018) found that mind maps have interactive and innovative properties, thus triggering students' interest in learning. Hidayad et al. (2020) also analyzed the need for developing a multimedia evaluation-based module that suits the needs of students is needed.

These studies support the positive results of mind map-based module development because they combine easy-to-use modules and interactive mind maps. Mind map-based modules, as a form of teaching material that is easy to use and interactive, can overcome students' difficulties in understanding the subject matter and overcome the limited variety of learning media.

D. Conclusion

Based on the analysis's findings, it can be said that the mind map-based module is fairly valid, receiving percentage scores of 68% from the Media Expert, 80% from the Material Expert, 90% from the Expert Question Instrument, and 95% from the Questionnaire Expert in the Very Valid category. According to the Practicality Test, mind map-based courses are also practical, scoring 90% in the Very Practical category and 100% for school biology teachers and students in the Very Practical category, respectively. Then, with an average score of 0.84 in the High category and an increase from the pre-test to the post-test, the mind map-based module used was effective. The restricted variety of learning media and students' challenges with the subject matter can be overcome using interactive, mind map-based modules as instructional material.

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