ALGEBRA : JURNAL PENDIDIKAN, SOSIAL DAN SAINS

ISSN : 2807-663X e-ISSN : 2807-629X
Journal Homepage : https://algebra.yana.or.id/index.php/ejournal/index
Volume 6 Number 2 (2026)

DEVELOPMENT OF ELECTRONIC STUDENT WORKSHEETS (E-LKPD) BASED ON DISCOVERY LEARNING ON ECOSYSTEM MATERIAL FOR GRADE X SENIOR HIGH SCHOOL

Leni Marlina[1*], Evi Suryawati[2], Fitra Suzanti[3]
[123]Program Studi Pendidikan Biologi, Fakultas Ilmu Keguruan dan Ilmu Pendidikan, Universitas Riau, Pekanbaru, Indonesia
Correspondence Email: leni.marlina5597@student.unri.ac.id

ABSTRACT

This study aims to determine the validity and practicality of Electronic Student Worksheets (E-LKPD) based on Discovery Learning on ecosystem material for Grade X senior high school. The research method used was Research and Development (R&D) with the ADDIE development model, which consists of five phases: Analysis, Design, Development, Implementation, and Evaluation. In this development research, the product developed was a learning resource in the form of Electronic Student Worksheets (E-LKPD) based on the Discovery Learning (DL) model on ecosystem material for Grade X senior high school. This development research was conducted only up to the development stage, which produced an E-LKPD that had been revised based on input from experts. The results of the development of the Discovery Learning–based E-LKPD on ecosystem material showed that the media expert validation categorized the E-LKPD as very valid with an average score of 3.70, while the material expert validation categorized it as very valid with an average score of 3.32. The results of the first trial stage obtained an average score of 3.78 in the very good category. The results of the second trial stage obtained an average score of 3.68 in the very good category. Overall, the Discovery Learning–based E-LKPD on ecosystem material that was developed met the criteria of validity and practicality, so it can be used as electronic teaching material to support active and interactive Biology learning in line with the demands of the Merdeka Curriculum.

Keywords: Discovery Learning; E-LKPD; Ecosystem Material; Practicality; Validity

INTRODUCTION

The rapid development of technology in today's digital era has brought major changes in various fields, including education and learning. Hanipah (2023) states that the learning paradigm has also shifted, where students need to be equipped with skills and competencies that are relevant to the modern world. In line with this, the curriculum transition from the 2013 Curriculum to the Merdeka Curriculum marks a significant shift in approaches, strategies, methods, and learning models. The Merdeka Curriculum emerges as a response to the increasingly intense global competition for human resources in the 21st century (Indarta et al., 2022) and has been officially established as the national curriculum through the Regulation of the Minister of Education, Culture, Research, and Technology Number 12 of 2024.

The Merdeka Curriculum emphasizes the development of 21st-century skills, such as critical, creative, collaborative, and communicative thinking, as well as digital literacy skills. In this context, technology plays an important role because it allows students to learn not only in the classroom but also independently through various online learning resources. Teachers are also required to be creative in designing and managing learning activities to make them more engaging and relevant to students' needs in the digital era (Kurniawan, 2018).

One subject that requires direct learning experiences is Biology, as it is closely related to natural phenomena and everyday life. Ecosystem material in Biology learning contains many abstract and complex concepts, such as interactions between biotic and abiotic components, food chains, and food webs. Therefore, students often need visualization and exploratory activities to understand these concepts deeply. The use of electronic media and teaching materials is one solution to help students understand these concepts more easily and attractively.

One form of teaching material that is relevant to the needs of 21st-century learning is the Electronic Student Worksheet (E-LKPD). According to Putri and Raharjo (2024), E-LKPD is a digital-format worksheet that is interactive, allowing students to learn more actively. E-LKPD has been proven to increase learning motivation, make learning more enjoyable and interactive, and provide opportunities for students to practice independently (Puspita & Dewi, 2021). This differs from printed LKPD, which tends to be static because it only contains text and images. In addition, E-LKPD can help teachers guide students in discovering concepts through observation, investigation, and experimental activities (Apriliyani & Mulyatna, 2021).

In the learning process, in addition to using appropriate media and teaching materials, suitable learning models are also needed to meet students' needs in ecosystem material. The government has proposed several learning models to complement the Merdeka Curriculum, one of which is the discovery learning model. This model refers to learning activities in which students are not given complete explanations of a topic but are assigned to plan how they will discover the topic themselves (Anggarwati et al., 2024). This learning model positions students as active subjects who independently discover concepts or principles through a series of activities such as observation, data collection, and drawing conclusions. Hosnan (2014) states that the Discovery Learning model encourages students to learn actively and independently, so the learning outcomes are more enduring in memory. In addition, Afdillah (2021) adds that this model is very suitable for science learning because it allows students to interact directly with their surrounding environment, making conceptual understanding more meaningful. This is supported by research by Asmal (2023), which states that the use of Discovery Learning has a positive effect on students' problem-solving abilities and learning outcomes compared to other learning models.

Based on interviews with several high school biology teachers in Pekanbaru, it was found that some teachers still apply lecture methods, question-and-answer discussions, and group learning that are dominated by teachers (teacher-centered), thus involving students less actively, even though current learning paradigm demands emphasize student-centered learning. This explanation is supported by Rudiana (2016), who states that the weakness of the lecture method is that students become passive, only listening and taking notes, resulting in low active participation and student engagement. In addition, teachers also use conventional LKPD that are still general, not interactive, and rely only on textbooks as learning resources, causing students to often experience boredom. This condition makes students tend to be passive and have difficulty understanding the material being taught. Furthermore, teachers have not maximized the use of electronic learning media as required by the Merdeka Curriculum.

Based on these problems, students may become less interested in participating in the learning process and quickly feel bored during learning. This will affect the decline in student learning

outcomes. To overcome this, improvements in classroom learning processes are needed. One solution to these problems is innovation in the form of developing E-LKPD based on discovery learning. According to Suwiti (2022), the implementation of learning using discovery learning-based E-LKPD has a positive impact on learning outcomes. Compared to using conventional LKPD without a learning model, students are less interested because the presentation is still text-based and focuses only on concepts without understanding their application in everyday life. This is supported by research by Salwan and Rahmatan (2017), which explains that E-LKPD integrated with the discovery learning model can improve conceptual understanding, critical thinking, and student learning outcomes.

Based on the background described above, a development study entitled "Development of Electronic Student Worksheets (E-LKPD) Based on Discovery Learning on Ecosystem Material for Grade X Senior High School" was conducted.

RESEARCH METHODS

E-LKPD Development Procedure

The procedure for conducting the development research to produce the product can be seen in Figure 1 below.

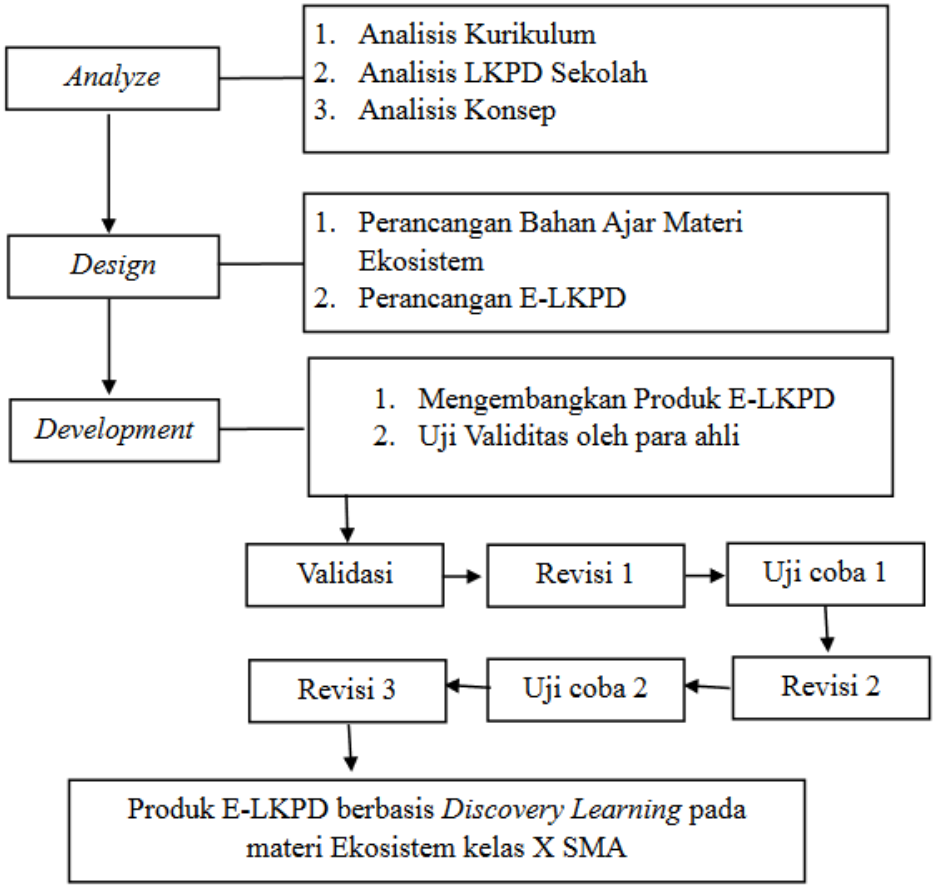


Figure 1. Development Flow of the Electronic Student Worksheet (E-LKPD)

Analysis Stage (Analyze)

At this stage, several analyses are conducted, including curriculum analysis, analysis of teaching materials used by teachers and students, and analysis of teachers' instructional tools.

a. Curriculum Analysis

The curriculum examined is the Merdeka Curriculum. The initial step of curriculum analysis is analyzing the Learning Outcomes (CP), Learning Objectives (TP), and Learning Objectives Flow (ATP), starting from the learning materials, time allocation, learning resources, and assessment.

b. School LKPD Analysis

The next stage is analyzing the suitability of the LKPD with the Merdeka Curriculum. The LKPD analyzed is the LKPD developed by the MGMP team (Subject Teacher Forum). This analysis aims to obtain an overview of the LKPD used by teachers, the LKPD that should be used in accordance with the Merdeka Curriculum, and to identify the strengths and weaknesses of the LKPD currently used by teachers.

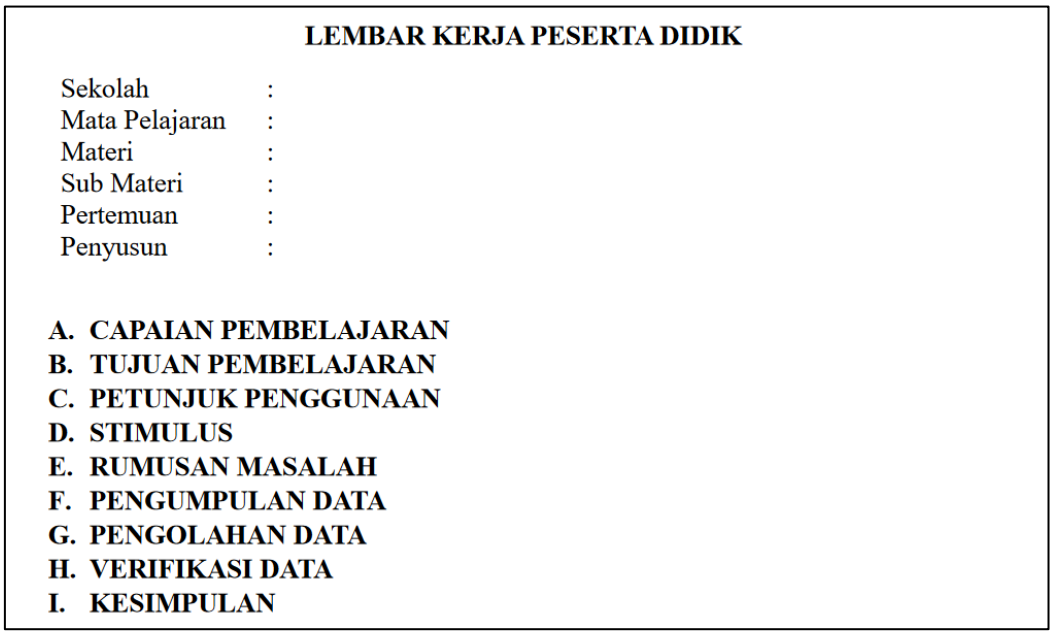
c. Material Concept Analysis

Concept analysis is conducted by identifying the main concepts studied in ecosystem material for Grade X senior high school. After the analysis, the learning objectives for ecosystem material in senior high school Biology learning are identified. The material discussed in each meeting based on CP Phase E on ecosystem material is as follows:

1) Meeting 1 discusses the components of ecosystems and their roles, and interactions among biotic components.
2) Meeting 2 discusses patterns of interaction among biotic components in the form of food chains and food webs, and types of ecological pyramids.
3) Meeting 3 discusses biogeochemical cycles.
4) Meeting 4 discusses environmental changes.

Design Stage (Design)

This stage is the design phase, which involves creating designs according to the specifications of learning objectives, designing teaching and learning activities, designing learning materials, and designing instructional tools in the form of Discovery Learning–based E-LKPD on ecosystem material. The E-LKPD is designed in accordance with the learning outcomes set in the Merdeka Curriculum and adjusted to the content of the material. The designed E-LKPD is also adjusted to the time allocation stated in the teaching module. The content of the designed E-LKPD consists of learning activities to be carried out by students. The E-LKPD design according to Permendikbudristek (2024) can be seen in Figure 2, and the designed Discovery Learning–based E-LKPD can be seen in Figure 2.



LEMBAR KERJA PESERTA DIDIK

Sekolah :
Mata Pelajaran :
Materi :
Sub Materi :
Pertemuan :
Penyusun :

A. CAPAIAN PEMBELAJARAN
B. TUJUAN PEMBELAJARAN
C. PETUNJUK PENGGUNAAN
D. STIMULUS
E. RUMUSAN MASALAH
F. PENGUMPULAN DATA
G. PENGOLAHAN DATA
H. VERIFIKASI DATA
I. KESIMPULAN

Figure 2. LKPD Design According to Permendikbudristek (2024)

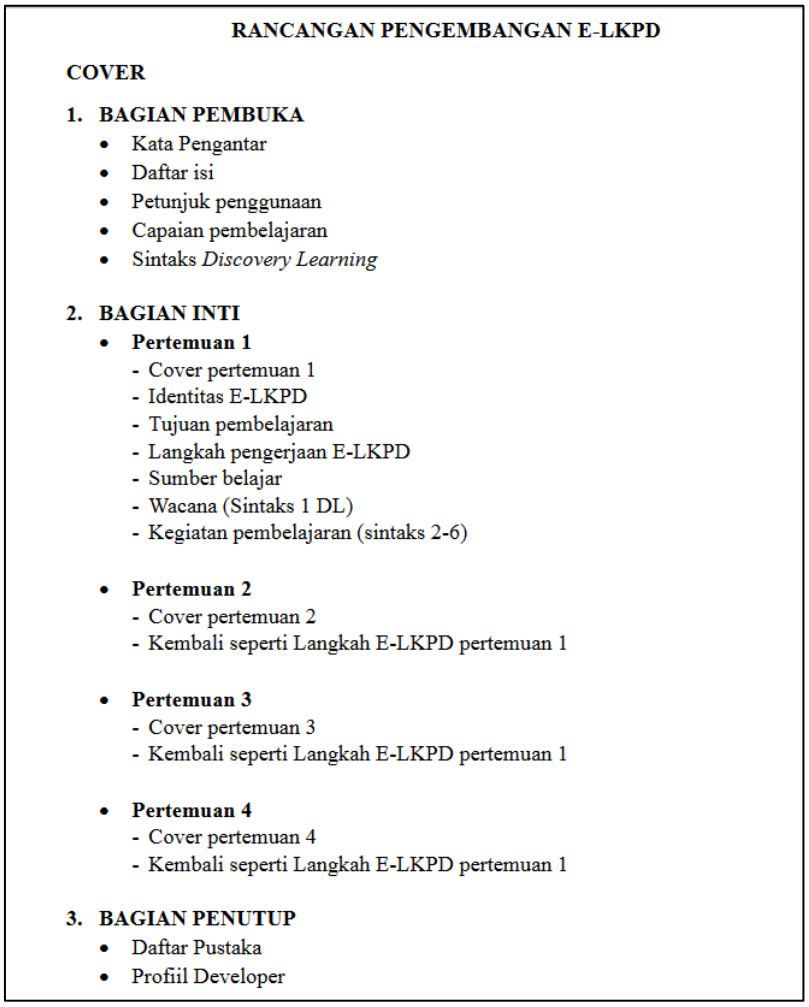


Figure 3. Design of the E-LKPD to Be Developed

Development Stage

The development stage is the phase of realizing what has been designed in the design stage. The purpose of this stage is to produce the designed E-LKPD using Liveworksheet, which is then validated, revised, and tested on university students and school students.

The development stage in this study involved developing a Discovery Learning–based E-LKPD designed for four meetings. The developed E-LKPD was then validated by four validators, consisting of one subject-matter expert lecturer, one media expert lecturer, and two Grade X senior high school biology teachers. The validation results were subsequently revised and followed by limited trials.

The first trial stage was conducted with 10 active Biology Education students at the University of Riau. This stage aimed to minimize errors in the E-LKPD on a small scale. The results of the first trial were then analyzed and revised. After that, the second trial stage was conducted with 30 students of Grade XI at SMAN 19 Pekanbaru. The results of the second trial were revised again to produce the final Discovery Learning–based E-LKPD product. The first and second trial stages were carried out to determine the usability of the E-LKPD in terms of structure, language use, and aesthetics in its development.

Data Analysis Techniques

Based on the data collection instruments presented, the next stage was data analysis to describe the results objectively and systematically according to the actual conditions in the field. The data analysis technique used was descriptive analysis by calculating the scores of each indicator used to determine the validity of the developed electronic LKPD. The required data analysis in this study is explained as follows:

Validity by Validators

The data analysis technique used in this study was descriptive analysis by calculating the scores of each indicator used to determine the validity of the developed E-LKPD. The validation aspects

assessed by experts or practitioners were arranged in the form of a rating scale. The type of scale used was a Likert interval scale with scores ranging from 1 to 4. The validity of the assessment instrument was determined by the average score given by the validators, which can be seen in Table 1 below.

Table 1. Validation assessment categories by validators for each E-LKPD

Assessment Score	Category
4	SB: Very Good
3	B: Good
2	KB: Less Good
1	TB: Not Good

(Source: Sugiyono, 2019)

The data obtained were then analyzed using descriptive quantitative analysis by calculating the percentage score of each item. According to the method for calculating the average validation score proposed by Khatimah et al. (2018), the following formula was used:

$$X = \frac{\Sigma x}{N}$$

Description:
X = Average score
Σx = Score given by the validators
N = Number of statement items

The criteria for making decisions on the validation of the electronic LKPD using the discovery learning model are presented in Table 2 and interpreted in qualitative form. The E-LKPD is considered feasible for use if it reaches the valid or very valid category. The validity criteria of the E-LKPD are shown in Table 2 below.

Table 2. Validity Criteria of the E-LKPD

No	Percentage Interval (%)	Interpretation Criteria
1	$3.25 < x \leq 4$	Very Valid
2	$2.5 < x \leq 3.25$	Valid
3	$1.75 < x \leq 2.5$	Less Valid
4	$1 < x \leq 1.75$	Not Valid

Limited Trial Analysis

The limited trial was conducted to examine the usability of the developed E-LKPD and to determine the responses of university students and school students toward the E-LKPD. The limited trial consisted of two stages: limited trial stage I and limited trial stage II. Limited trial stage I was conducted with 10 students from the Biology Education study program. Subsequently, limited trial stage II was conducted with 30 students of grade XI at SMA Negeri 19 Pekanbaru. The categorization of the limited trial questionnaire assessment is presented in Table 3 below.

Table 3. Categories of the Limited Trial Questionnaire

Assessment Score	Categoriy
4	SB: Very Good
3	B: Good
2	KB: Less Good
1	TB: Not Good

(Source: Sugiyono, 2019)

The students' response results were calculated using the average score formula by Khatimah et al. (2018), as follows:

$$X = \frac{\Sigma x}{N}$$

Description:
X = Average score
Σx = Score given by the respondents
N = Number of statement items

The criteria for decision-making based on the score of each item obtained are presented in the following table.

Table 4. Interval and Category of the Questionnaire

No	Persentase Interval (%)	Kriteria Interpretasi
1	3.25 < x ≤ 4	Sangat Baik
2	2.5 < x ≤ 3.25	Baik
3	1.75 < x ≤ 2.5	Kurang Baik
4	1< x ≤ 1.75	Tidak Baik

(Source: Sugiyono, 2019)

RESULTS AND DISCUSSION

The development of E-LKPD teaching materials followed the ADDIE model, which includes three stages, namely analyze, design, and development, described as follows:

Analysis

The first stage conducted in this study was the analysis stage. The results of each analysis are described as follows:

Curriculum Analysis

The researcher analyzed the Learning Outcomes (Capaian Pembelajaran/CP) in the Merdeka Curriculum to obtain indicators and Learning Objectives (Tujuan Pembelajaran/TP). The analyzed learning outcomes were those at Phase E. The learning outcomes are presented in Table 5 below.

Table 5. Biology Learning Outcomes Phase E

Element	Learning Outcomes
Biology Understanding	At the end of Phase E, students are able to apply classification principles and biodiversity conservation strategies; describe the roles of viruses, bacteria, and fungi in life; and analyze interactions among ecosystem components and their effects on ecosystem balance.
Process Skills	At the end of Phase E, students are expected to be able to conduct simple research activities using appropriate techniques or methods, including (1) observing, (2) questioning and predicting, (3) planning and conducting investigations, (4) processing and analyzing data and information, (5) evaluating and reflecting, and (6) communicating results.

After analyzing the Learning Outcomes (CP) in the Merdeka Curriculum, the next step was analyzing the Learning Objectives Flow (Alur Tujuan Pembelajaran/ATP). The ATP analysis was needed to determine the extent to which the Merdeka Curriculum demands the developed learning outcomes.

Analysis of Material Concepts

The analysis of material concepts was carried out by identifying ecosystem material concepts to determine the scope of the Merdeka Curriculum demands on learning outcomes and learning objectives to be developed, so that the subtopics of ecosystem material in the developed E-LKPD could be determined. The results of the ecosystem material concept analysis for Grade X SMA are presented in Table 6 below.

Table 6. Analysis of Ecosystem Material Concepts for Grade X SMA

Main Material	Sub-material/LKPD Topic	Learning Objectives	Meeting
Ecosystem	Ecosystem components and their roles; interactions among biotic components	Identify biotic and abiotic components of ecosystems and their roles in maintaining environmental balance	1
		Explain various types of interactions among biotic components in ecosystems	
	Patterns of interactions among biotic	Illustrate interaction patterns among biotic components in the form of food chains and food webs	2

components in the form of food chains, food webs, and types of ecological pyramids	Distinguish types of ecological pyramids	
Biogeochemical cycles	Analyze biogeochemical cycles	3
Environmental change	Identify factors causing environmental change, both natural and due to human activities	4
	Evaluate the impact of environmental change on the sustainability of living organisms and ecosystem balance	
	Design simple solutions/actions to preserve the environment	

Based on Table 6, it can be seen that the results of the concept analysis produced four main subtopics with four E-LKPD titles for four meetings. E-LKPD Meeting 1 covers ecosystem components and their roles, and interactions among biotic components. E-LKPD Meeting 2 covers interaction patterns among biotic components in the form of food chains, food webs, and types of ecological pyramids. E-LKPD Meeting 3 covers biogeochemical cycles. E-LKPD Meeting 4 covers environmental change.

Analysis of School LKPD

The results of observations on the Biology LKPD for Grade X SMA used by the school are presented in Appendix 3. The analysis of the school LKPD is described as follows:

1. LKPD appearance: The appearance is still simple (conventional) with minimal visual elements. The layout is text-heavy and has not yet attracted students' visual attention.
2. LKPD presentation: It already includes basic competencies and learning objectives, but these are still general and not specific to each meeting. There is no reference list, and the Discovery Learning model has not been applied because activities are still concept-oriented (students receive ready-made knowledge), not discovery-oriented (there is no exploration, observation, data analysis, or independent conclusion drawing by students).
3. Material relevance: The material is scientifically accurate in biology, but it has not been linked to current phenomena related to ecosystems.
4. Discourse: There is no introductory discourse in the form of narratives, cases, or environmental issues that could trigger students' curiosity. The LKPD directly presents images of several types of interactions without introductory narratives. In fact, discourse is very important to provide problem orientation and increase students' learning motivation, such as curiosity, enthusiasm, and active involvement in discovery-based learning.
5. Work instructions: The instructions are fairly clear but still procedural in nature. The duration of task completion is not specified. Structurally, the LKPD follows the Discovery Learning pattern, but the syntax is incomplete and not explicitly explained for each stage (stimulation, problem statement, data collection, data processing, verification, and generalization), causing student activities to remain passive.

Design

The design stage involved developing learning tools for ecosystem material and Discovery Learning–based E-LKPD teaching materials using several applications such as Canva, Liveworksheet, and Heyzine. The final format of the developed E-LKPD is presented in the form of a link. The design stage included the following steps:

Learning Tools Design

The results of the teaching material design consisted of the design of the Learning Objectives Flow (ATP) and the Teaching Model, described as follows:

Design of Learning Objectives Flow (ATP)

The Learning Objectives Flow (ATP) was designed based on the format of Permendikbudristek (2024), as shown in Figure 4. Prior to this design stage, an analysis of the Merdeka Curriculum had

been conducted through interviews and observations of learning tools together with teachers at the school.

Figure 4. ATP Format According to Permendikbudristek (2024)

ALUR TUJUAN PEMBELAJARAN

SMA/SMK_____

TAHUN PELAJARAN 20__/20__

Nama Mata Pelajaran :.....
Kelas/Fase :...../.....

ELEMEN	CAPAIAN PEMBELAJARAN	TUJUAN PEMBELAJARAN	ALUR TUJUAN PEMBELAJARAN

Mengetahui,
Kepala,_____

(_____)
NIP.

_____,_____20__
Guru Mata Pelajaran

(_____)
NIP.

The ATP format includes columns for elements and learning outcomes, allocation of instructional hours, and the flow of learning objectives. Revisions to this ATP were adjusted to the needs of developing the E-LKPD. In this study, the researcher did not develop a new ATP but added material topics, main materials, learning activities, the Pancasila Student Profile, assessment, and learning resources. The appearance of the developed ATP format is described in Appendix 8 and summarized in Figure 5 below.

Figure 5. Developed ATP Design Format

ALUR TUJUAN PEMBELAJARAN

Sekolah : SMAN_____
Nama Penyusun :_____
Mata Pelajaran :_____
Fase :_____
Kelas /Semester :_____/_____
Tahun Ajaran :_____

Elemen	Capaian Pembelajaran
Pemahaman IPA-Biologi	
Pemahaman Proses	

Tujuan Pembelajaran	Topik Materi	Materi Pokok	Kegiatan Pembelajaran	Profil pelajar pancasila	Penilaian / Asessmen	Sumber Belajar

Mengetahui,
Kepala,_____

(_____)
NIP.

_____,_____20__
Guru Mata Pelajaran

(_____)
NIP.

Teaching Module Design

The teaching module design was developed from the ATP with the aim of directing learning activities in accordance with subject characteristics so that students can achieve the learning outcomes. The teaching module design follows the format provided by Permendikbudristek (2024), which can be seen in Figure 6, while the developed teaching module is described in Appendix 9 and presented in Figure 7 below.

Figure 6. Teaching Module Format according to Permendikbudristek (2024)

MODUL AJAR

INFORMASI UMUM

A. IDENTITAS MODUL

B. KOMPETENSI AWAL

C. PROFIL PELAJAR PANCASILA

D. SARANA DAN PRASARANA

E. TARGET PESERTA DIDIK

F. JUMLAH PESERTA DIDIK

G. MODEL PEMBELAJARAN

KOMPONEN INTI

A. TUJUAN PEMBELAJARAN

B. PEMAHAMAN BERMAKNA

C. PERTANYAAN PEMANTIK

D. PERSIAPAN BELAJAR

E. KEGIATAN PEMBELAJARAN

F. REFLEKSI

G. ASESSMEN/PENILAIAN

H. KEGIATAN PENGAYAAN DAN REMEDIAL

LAMPIRAN-LAMPIRAN

Figure 7. Format of the Teaching Module to Be Developed

MODUL AJAR

A. INFORMASI UMUM

Mata Pelajaran	Fase	Kelas	Semester	Tahun Pembelajaran
Alokasi Waktu	Pertemuan		Penulis Modul Ajar	
Kompetensi Awal				
Profil Pelajar Pancasila	Dimensi		Elemen	
Sarana dan Prasarana				
Target Siswa				
Moda Pembelajaran				
Model & metode pembelajaran				

B. KOMPONEN INTI

No	Komponen	Deskripsi/Uraian		
1	Tujuan Pembelajran			
2	Pemahaman Bermakna			
3	Pertanyaan Pemantik			
4	Persiapan Pembelajaran			
5	Kegiatan pembelajaran			
	Langkah Kegiatan	Alokasi Pembelajaran	Alokasi Waktu	
6	Asessmen			
	Diagnostik	Formatif	Sumatif	
7	Pengayaan & Remedial			
8	Refleksi Guru & Siswa			

C. LAMPIRAN

Design of the E-LKPD

At this stage, the researcher designed the E-LKPD by determining the learning model, the format of teaching materials, and making modifications to the teaching materials. The development and selection of the teaching material model were adjusted to students' needs and its suitability to the learning environment. Canva, Liveworksheet, and Heyzine were used as supporting applications to facilitate material presentation and enable the use of various multimedia such as images, audio, video, and animation in the Discovery Learning (DL)-based E-LKPD. The E-LKPD design process is as follows:

1) Designing the appearance of the E-LKPD to be developed. The LKPD display format according to Permendikbudristek (2024) can be seen in Figure 2, and the developed E-LKPD design can be seen in Figure 3.

2) After designing the E-LKPD layout, the design was realized using the Canva application to create the E-LKPD display. The visual storyline design of the Discovery Learning-based E-LKPD is presented in the storyboard description.
3) After the E-LKPD design was created using Canva, the design was downloaded in JPG or PNG format and uploaded to Liveworksheet to add supporting elements to the E-LKPD content.
4) After editing the elements in Liveworksheet, the access links for each E-LKPD meeting were compiled into the main E-LKPD designed in Canva and downloaded in PDF format to be uploaded to Heyzine, thus displaying it as an electronic LKPD.

Development

The final stage of this research is the development stage. This stage involved developing learning tools, namely the learning objectives flow (ATP), teaching modules, and Discovery Learning-based E-LKPD on ecosystem material.

Learning Objectives Flow (ATP)

The development stage began with developing the ATP established by Permendikbudristek and reconstructing several aspects by the researcher, such as learning activities, Pancasila student profile, assessment, and learning resources. In addition, the researcher also adjusted it to the learning time. The results of the developed ATP are shown in Figure 8 below.

Figure 8. Display of the Developed ATP

Lampiran 8. Alur Tujuan Pembelajaran

ALUR TUJUAN PEMBELAJARAN

Satuan Pendidikan : SMA/MA
Penyusun : Leni Marlina
Mata Pelajaran : Biologi
Fase / Kelas : E / X
Semester Genap : Genap
Tahun Ajaran :2025/2026

Elemen	Capaian Pembelajaran
Pemahaman IPA	Pada akhir fase E, peserta didik memiliki kemampuan menerapkan prinsip klasifikasi dan strategi pelestarian keanekaragaman hayati; mendeskripsikan peranan virus, bakteri, dan jamur dalam kehidupan; menganalisis interaksi antar komponen ekosistem dan pengaruhnya terhadap keseimbangan ekosistem; menggunakan sistem pengukuran dalam kerja ilmiah; menganalisis Gerak dua dimensi; menganalisis pemanfaatan energi alternatif untuk mengatasi permasalahan ketersediaan energi; menganalisis partikel penyusun materi dan menerapkan konsep stoikiometri dalam berbagai aspek kuantitatif reaksi kimia; dan menerapkan konsep IPA untuk mengatasi permasalahan berkaitan dengan perubahan iklim.
Keterampilan Proses	**1. Mengamati** Peserta didik mengamati fenomena ilmiah dan mencatat hasil pengamatannya dengan memperhatikan karakteristik dari objek yang diamati untuk memunculkan pertanyaan yang akan diselidiki **2. Mempertanyakan dan memprediksi** Peserta didik mengidentifikasi pertanyaan dan permasalahan yang dapat diselidiki secara ilmiah. Peserta didik menghubungkan pengetahuan yang telah dimiliki dengan pengetahuan baru untuk membuat prediksi. **3. Merencanakan dan melakukan penyelidikan** Peserta didik merencanakan penyelidikan ilmiah dan melakukan langkah-langkah operasional berdasarkan referensi yang benar untuk menjawab pertanyaan. Peserta didik melakukan mengukuran atau membandingkan variabel terikat dengan menggunakan alat yang sesuai serta memperhatikan kaidah ilmiah. **4. Memproses, menganalisis data dan informasi** Peserta didik menafsirkan informasi yang diperoleh dengan jujur dan bertanggung jawab. Peserta didik menganalisis menggunakan alat dan metode yang tepat berdasarkan data penyelidikan dengan menggunakan referensi rujukan yang sesuai, serta menyimpulkan hasil penyelidikan **5. Mengevaluasi dan refleksi**

Teaching Module

The next stage is the development of the teaching module. The teaching module was created following the module format designed at the design stage. The development of the teaching module in this study resulted in four meetings on the ecosystem topic. The developed teaching module was adjusted to the needs of the E-LKPD being developed, while still referring to the Merdeka Curriculum, and was developed using the discovery learning model. The teaching module is shown in Figure 9 below.

Figure 9. Display of the Developed Teaching Module

Lampiran 9. Modul Ajar Pertemuan 1

a) Modul ajar pertemuan 1

MODUL AJAR

A. INFORMASI UMUM

Mata Pelajaran	**Fase**	**Kelas**	**Semester**	**Tahun Pelajaran**
Biologi	E	X	2	2025/2026
Alokasi waktu	**Pertemuan**		**Penulis Modul Ajar**	
2 JP	1		Leni Marlina	
Kompetensi Awal	Peserta didik memiliki pengetahuan tentang jenis-jenis makhluk hidup dan lingkungannya yang telah dipelajari di jenjang sebelumnya, serta mampu mengamati dan mengelompokkan makhluk hidup berdasarkan ciri-ciri tertentu.			
Profil Pelajar Pancasila	**Dimensi**		**Elemen**	
	• Beriman, bertaqwa kepada Tuhan YME dan berakhlak mulia		Beriman dan bertaqwa kepada tuhan YME, memiliki rasa kagum dan bersyukur terhadap pencipta (sikap spiritual) serta menghormati makhluk hidup dan ikut serta menjaga lingkungan.	
	• Berkebhinekaan global		Refleksi dan tanggung jawab terhadap pengalaman kebhinekaan	
	• Bergototng royong		Kolaborasi	
	• Mandiri		Pemahaman diri dan situasi yang dihadapi	
	• Bernalar kritis		Merefleksi pemikiran dan proses berfikir dalam mengambil Keputusan	
	• Kreatif		Memiliki keluwesan berfikir dalam mencari Solusi permasalahan	
Sarana dan prasarana	• Laptop/Hp • Akses internet • E-LKPD Pertemuan 1 : • Sumber belajar: - Campbell, N. A., Reece, J. B., Urry, L. A., Cain, M. L., Wasserman, S. A., Minorsky, P. V., & Jackson, R. B. (2021). *Campbell biology* (12th ed.). Pearson Education. - Irnaningtyas, & Sagita, S. (2021). *IPA Biologi untuk SMA/MA Kelas X (Kurikulum Merdeka)*. Jakarta: Erlangga.			

E-LKPD

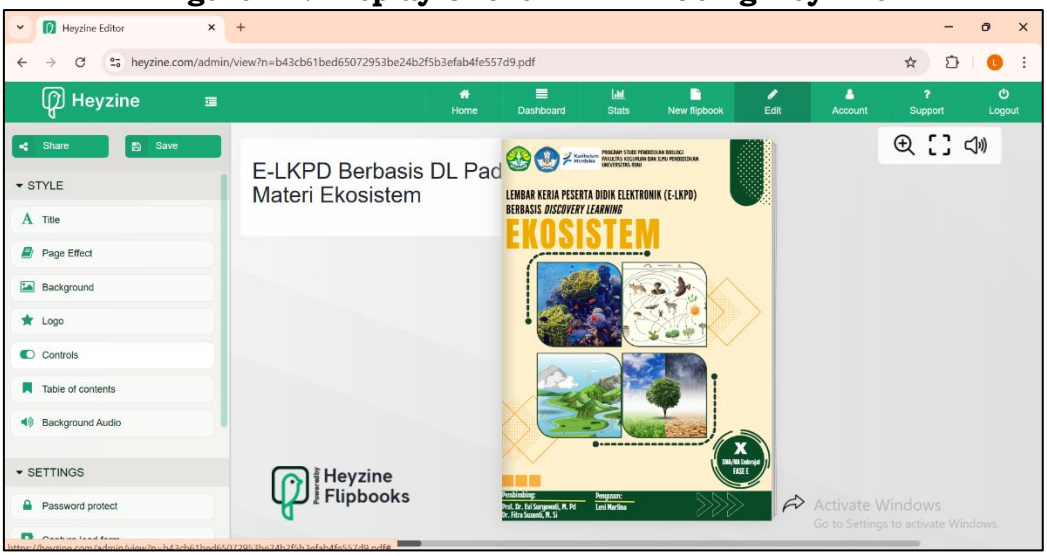
The results of the E-LKPD design consist of the following steps:

1) The E-LKPD design results consist of four main parts, namely the cover, opening section, content, and closing section. An explanation of the E-LKPD design results is provided.
2) After the E-LKPD design was created using Canva, the next stage was downloading the design in JPG or PNG format, then uploading it to Liveworksheet to add supporting elements to the display content of the developed E-LKPD.

Figure 10. Editing Display in Liveworksheet

3) After editing the elements in Liveworksheet, the access links for the E-LKPD for each meeting are combined into the main E-LKPD designed in Canva and downloaded in PDF format, then uploaded to Heyzine so that it is displayed as an electronic LKPD.

Figure 11. Display of the E-LKPD Using Heyzine



Results of the Validation of Discovery Learning–Based E-LKPD on Ecosystem Material for Grade X Senior High School

After the E-LKPD was designed and edited, the next stage was product validation. The assessment of the E-LKPD by validators consisted of media expert validation and content expert validation using validation sheets to assess the level of validity of the developed E-LKPD. The validators consisted of two lecturers from the Biology Education Study Program, FKIP, University of Riau, and two senior high school biology teachers. The overall validation results can be seen in Appendix 15 and Appendix 16. The average validity scores of the Discovery Learning–based E-LKPD on ecosystem material for each section are described as follows:

Media Expert Validation

Media validation was conducted by one lecturer from the Biology Education Study Program, FKIP, University of Riau, one biology teacher from SMAN 8 Pekanbaru, and one teacher from SMAN 19 Pekanbaru as media experts. The analysis of media validation data is presented in Appendix 15 and summarized in Table 12 below.

Table 12. Validation of E-LKPD by Media Expert Validators

No	Aspect	Score				Average	Category
		1	2	3	4		
1	Media Presentation	3.83	3.75	3.75	3.75	3.77	SV
2	Graphic Feasibility (E-LKPD Cover Design)	3.78	3.78	3.78	3.89	3.81	SV
3	Graphic Feasibility (E-LKPD Content Design)	3.78	3.89	3.78	3.89	3.83	SV
4	Accuracy of Image, Illustration, and Video Use	4.00	3.83	3.67	4.00	3.88	SV
5	Quality of E-LKPD Display	3.89	3.78	3.56	3.89	3.78	SV
6	Systematics of E-LKPD Use	3.33	3.33	3.33	3.33	3.33	SV
7	Validity of Language Presentation	3.56	3.56	3.56	3.56	3.56	SV
Average of aspects		**3.74**	**3.70**	**3.63**	**3.75**	**3,70**	SV
Category		SV	SV	SV	SV	SV	

Note: SV = Very Valid

Based on Table 12, it can be seen that the average of the seven assessment aspects obtained an overall mean percentage of 3.70 for each session in the E-LKPD, categorized as very valid. Detailing the overall mean results obtained, the first session of the E-LKPD achieved an average of 3.74, categorized as very valid based on the overall mean of the assessment aspects; the second session of the E-LKPD obtained an average of 3.70, categorized as very valid; the third session of the E-LKPD obtained an average of 3.63, categorized as very valid; and the fourth session of the E-LKPD achieved an average of 3.75, categorized as very valid based on the overall mean of the media validation assessment aspects.

The overall average for each session in the E-LKPD on the media presentation aspect was 3.77, categorized as very valid; the overall average for the graphic feasibility of the cover design aspect was 3.81, categorized as very valid; the overall average for the graphic feasibility of the content design aspect was 3.83, categorized as very valid; the overall average for the accuracy in using images, illustrations, and videos aspect was 3.88, categorized as very valid; the overall average for the E-LKPD display quality aspect was 3.78, categorized as very valid; the overall average for the systematic use of the E-LKPD aspect was 3.33, categorized as very valid; and the overall average for the language presentation validity aspect was 3.56, categorized as very valid.

Content Expert Validation

Content validation was conducted by one lecturer from the Biology Education Study Program, FKIP, University of Riau, one biology teacher from SMAN 8 Pekanbaru, and one biology teacher from SMAN 19 Pekanbaru as content experts. The analysis of content validation data is presented in Appendix 16 and summarized in Table 13 below.

Table 13. Validation of E-LKPD by Content Expert Validators

No	Aspect	Score				Average	Category
		1	2	3	4		
1	Content Validity	3.27	3.27	3.40	3.20	3.28	SV
2	Presentation Validity	3.33	3.33	3.33	3.44	3.36	SV
Average of aspects		3.30	3.30	3.37	3.32	3.32	SV
Category		SV	SV	SV	SV	SV	

Note: SV = Very Valid

Based on Table 13, it can be seen that the average of the two assessment aspects obtained an overall mean percentage of 3.32 for each session in the E-LKPD, categorized as very valid. Detailing the overall mean results obtained, the first session of the E-LKPD achieved an average of 3.30, categorized as very valid based on the overall mean of the assessment aspects; the second session of the E-LKPD obtained an average of 3.30, categorized as very valid; the third session of the E-LKPD

obtained an average of 3.37, categorized as very valid; and the fourth session of the E-LKPD achieved a percentage of 3.32, categorized as very valid based on the overall mean of the material validation assessment aspects.

The overall mean for each session in the E-LKPD on the content validity aspect was 3.28, categorized as very valid, and the overall mean for each session on the presentation validity aspect was 3.36, categorized as very valid.

Results of Limited Trials of Discovery Learning–Based E-LKPD on Ecosystem Material for Grade X Senior High School

The limited trial stage was conducted after the E-LKPD was validated. Suggestions and comments from validators were used to revise the E-LKPD before the limited trials. The trials consisted of two stages: stage 1 with fifth-semester Biology Education students and stage 2 with 30 students of grade XI at SMAN 19 Pekanbaru. The results are described as follows:

Limited Trial Stage 1

The stage 1 trial was conducted on October 11, 2025, involving Biology Education students from the Department of Mathematics and Natural Sciences Education (PMIPA), Faculty of Teacher Training and Education (FKIP), Universitas Riau. The respondents in the stage 1 trial were 10 fifth-semester students. The students worked on the E-LKPD that had been revised based on the results of validation by the validators. After completing the E-LKPD, the students were given a response questionnaire to identify their suggestions regarding the E-LKPD they had worked on.

Based on the results of data analysis, student responses in the trial of the Discovery Learning–based E-LKPD on ecosystem topics can be seen in Table 14 below.

Table 14. Recapitulation of Limited Trial Stage 1 Assessment by Students

No	Aspect	Score				Average	Category
		1	2	3	4		
1	Content Feasibility	3.60	3.76	3.70	3.78	3.71	SB
2	Design	3.70	3.75	3.74	3.81	3.75	SB
3	Pedagogical Aspect	3.88	3.89	3.89	3.85	3.88	SB
Average of aspects		3.73	3.80	3.78	3.81	3.78	SB
Category		SB	SB	SB	SB	SB	

Note: SB = Very Good

Based on Table 14, it can be seen that from the three assessment aspects, the average percentage of assessment for each session in the E-LKPD was 3.78, with an interpretation of very good. Detailing the overall mean results obtained, the first session of the E-LKPD achieved an average of 3.73, categorized as very good based on the overall mean of the assessment aspects; the second session obtained an average of 3.80, categorized as very good; the third session obtained an average of 3.78, categorized as very good; and the fourth session achieved an average of 3.81, categorized as very good based on the overall mean of the E-LKPD assessment aspects.

The overall mean for each session in the E-LKPD on the content feasibility aspect was 3.71, categorized as very good; on the design aspect, it was 3.78, categorized as very good; and on the pedagogical aspect, it was 3.88, categorized as very good.

Limited Trial Phase 2

The second trial was conducted on October 17, 2025, with 30 eleventh-grade students of SMAN 19 Pekanbaru. The students completed the E-LKPD, which had been revised based on the results of the first trial. After completing the E-LKPD, the students were given a response questionnaire to gather suggestions regarding the E-LKPD they had worked on. The results of the student respondents' questionnaires can be seen in Table 15 below.

Table 15. Summary of Second Trial Assessment on Students

No	Aspect	E-LKPD				Average	Category
		1	2	3	4		
1	Content Quality	3.58	3.68	3.66	3.66	3.65	SB
2	Display	3.67	3.69	3.68	3.73	3.69	SB
3	Usefulness	3.72	3.72	3.67	3.73	3.71	SB
4	Usability	3.69	3.68	3.60	3.72	3.67	SB
Rerata		**3.66**	**3.69**	**3.65**	**3.71**	**3.68**	**SB**
Interpretation Criteria		**SB**	**SB**	**SB**	**SB**	**SB**	

Note: SB = Very Good

Based on Table 15, it can be seen that from the four assessment aspects, the average rating for each session in the E-LKPD was 3.68, with an interpretation of very good. Detailing the overall mean results obtained, the first session of the E-LKPD achieved an average of 3.66, categorized as very good based on the overall mean of the assessment aspects; the second session obtained an average of 3.69, categorized as very good; the third session obtained an average of 3.65, categorized as very good; and the fourth session achieved an average of 3.71, categorized as very good based on the overall mean of the E-LKPD assessment aspects.

The overall mean for each session in the E-LKPD on the content quality aspect was 3.65, categorized as very good; on the display aspect, it was 3.69, categorized as very good; on the usefulness aspect, it was 3.71, categorized as very good; and on the usage aspect, it was 3.67, categorized as very good.

CONCLUSIONS

Based on the development research of the Discovery Learning-based E-LKPD on the ecosystem material, the media expert validation of the E-LKPD was categorized as very valid with an average score of 3.70, and the material expert validation was also categorized as very valid with an average score of 3.32. The first trial obtained an average score of 3.78, categorized as very good, while the second trial obtained an average score of 3.68, also categorized as very good. Overall, the Discovery Learning-based E-LKPD on ecosystem material developed meets the criteria for validity and practicality, making it suitable to be used as an electronic learning resource to support active, interactive Biology learning in line with the demands of the Merdeka Curriculum.

BIBLIOGRAPHY

Afdillah, N. (2021). "Meningkatkan Hasil Belajar Siswa Dengan Metode *Discovery Learning* Tentang Tumbuhan Dan Fungsi Bagian-Bagiannya Di Kelas IV Madrasah Ibtidaiyah Muhammadiyah 3 Penatarsewu Tanggulangin Sidoarjo." *Journal of Chemical Information and Modeling* 53(9):1689–99.

Anggarwati, M. G., Ningsih, K., & Titin. (2024). *Pengembangan lembar kerja peserta didik berbasis discovery learning dengan pendekatan saintifik pada materi struktur dan fungsi tumbuhan*. Jurnal Ilmiah Edukatif, 10(1), 83–97. https://doi.org/10.37567/jie.v10i1.2955

Apriliyani, S., & Mulyatna, F. (2021). Pengembangan E-LKPD Interaktif Berbasis Discovery Learning untuk Meningkatkan Aktivitas Belajar Peserta Didik. *Jurnal Inovasi Pendidikan Sains (JIPS)*, 2(4), 490–496.

Arsyad, Muhammad, & Elysa Febriana Fahira. (2023). *Model Pembelajaran Dalam Kurikulum Merdeka.*

Asmal, Muthmainnah. (2023). "Perbandingan Model Pembelajaran Problem Based Learning dan *Discovery Learning* Terhadap Hasil Belajar Siswa." *Journal on Education* 5(2):5413–20. doi: 10.31004/joe.v5i2.1287.

Febriani, R. A. (2023). *Pengembangan lembar kerja peserta didik (LKPD) berbasis discovery learning pada materi perubahan lingkungan kelas X SMA/MA* (Disertasi doktor). Institut Agama Islam Negeri Metro.

Hanipah, Sri. (2023). "Analisis Kurikulum Merdeka Belajar Dalam Memfasilitasi Pembelajaran Abad Ke-21 Pada Siswa Menengah Atas." *Jurnal Bintang Pendidikan Indonesia (JUBPI)* 1(2):264–75.

Hosnan. (2014). *Pendekatan Saintifik dan Kontekstual dalam Pembelajaran Abad 21: Kunci Sukses Implementasi Kurikulum 2013*. Bogor: Ghalia Indonesia.

Indarta, Yose, Nizwardi Jalinus, Waskito, Agariadne Dwinggo Samala, Afif Rahman Riyanda, & Novi Hendri Adi. (2022). "Relevansi Kurikulum Merdeka Belajar Dengan Model Pembelajaran Abad 21 Dalam Perkembangan Era Society 5.0." *Edukatif : Jurnal Ilmu Pendidikan* 4(2):3011–24. doi: 10.31004/edukatif.v4i2.2589.

Khatimah, H., *et al.* 2018. "Pengembangan LKS Berbasis Kearifan Lokal Untuk Peningkatan Keterampilan Penyelesaian Masalah Siswa". *Bioscientist:Jurnal Ilmu Biologi, 6(2):173-178*

Kurniawan, Fajar. (2018). "Pengembangan E-Handout Pembelajaran Biologi Berbasis Android Pada Materi Virus Untuk Siswa SMA/MA."

Muhammad, Fikri Nur. (2022). "Pengembangan E-Lkpd Berbasis *Discovery Learning* Berbantuan *Google Docs* Untuk Menumbuhkan *Higher Order Thinking Skills* Peserta Didik." 1–23.

Puspita, Vivi, & Dewi, N. P. (2021). "Efektifitas E-LKPD Berbasis Pendekatan Investigasi Terhadap Kemampuan Berfikir Kritis Siswa Sekolah Dasar." *Jurnal Cendekia : Jurnal Pendidikan Matematika* 5(1):86–96. doi: 10.31004/cendekia.v5i1.456.

Putri, D. A., & Raharjo, M. (2024). "Pengembangan E-LKPD Berbasis Website Liveworksheets Dengan Model *Discovery Learning* Pada Pembelajaran IPAS Di Sekolah Dasar." *SITTAH: Journal of Primary Education* 5(1):17–32. doi: 10.30762/sittah.v5i1.2653.

Rudiana. (2016). *Meningkatkan Prestasi Belajar Ipa Melalui Gabungan Metode Ceramah Dengan Metode Kooperatif Model TPS (Think Pair Share) Pada Siswa Kelas IXB MTS NEGERI MUARA JAWA Tahun Pelajaran 2014/2015*. *X*, 103–117.

Salwan, & Rahmatan, H. (2017). *Pengaruh LKPD Berbasis Discovery Learning terhadap Peningkatan Hasil Belajar Siswa*. *5*(2), 25–31. https://doi.org/10.24815/jpsi.v5i2.9812

Suwiti, Ni Ketut. (2022). "Implementasi Model Pembelajaran *Discovery Learning* Untuk Meningkatkan Hasil Belajar Bahasa Indonesia." I*ndonesian Journal of Educational Development* 2(4):89–96. doi: 10.5281/zenodo.6204383.