

Development of interactive e-LKPD based on creative thinking skills on the concept of environmental change

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Abstract: Students' worksheets (*Lembar Kerja Peserta Didik/LKPD*) are needed as alternative teaching materials in learning. This study aims to produce electronic students' worksheets (e-LKPD) based on creative thinking skills on the concept of environmental change. In addition, this study also aims to determine the level of validity, readability, and practicality of the Interactive e-LKPD developed. The research method used is Developmental Research using the stages of Akker et al which consists of 3 stages, namely: Analysis, Design and Development, and Evaluation Phase. Validity test results obtained an average percentage value of 90.06% with a very valid category. The readability test results obtained an average percentage value of 94.91% with a very positive category. The results of the practical test by biology teachers and students obtained an average percentage of 100% and 81.22%, with both categories being very practical. Based on the test results that have been done, it can be concluded that the Interactive E-LKPD is very feasible to use in learning activities. Therefore, the existence of interactive E-LKPD as a source of alternative teaching materials to develop students creative thinking skills in biology learning is in line with the implementation of Kurikulum Merdeka (Freedom Curriculum).

Keywords: Creative thinking skills; environmental change; interactive e-LKPD

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Introduction

The purpose of National Education contained in law No. 20 of 2003 on the National Education system requires the development of the potential of students who have the character of faith, piety, noble character, creativity, and independence. Efforts to realize Human Resources (HR) are affective, faithful, innovative, creative, and productive through the implementation of curriculum 2013 (Yunus & Alam, 2015; Zhang et al., 2022). The 2013 curriculum underwent several changes, but changes were only found in aspects that were administrative, assessment, or the use of terminology (Rahmat, 2021). The 2013 curriculum improvement aims to adapt to real life and meet the needs of the 21st century (Mulyasa, 2018). The 2013 curriculum is also oriented to scientific activities in the form of observing, questioning, experimenting, and communicating; as well as the ability of students to think at a high level (Darwis et al., 2022; Zulfiani et al., 2018).

The learning process in the revised 2013 curriculum has changed its orientation from being centered on educators to learners (Rahmat, 2021). Students not only gain knowledge transfer from educators but can explore and construct their knowledge independently. In addition, learning is also expected to develop the creativity of students. The formation of creative learners is obtained through observation of natural phenomena, culture, and social dams around it, then reasoning against the results of these

observations (Fuhse, 2022; Maker et al., 2023).

The current era of learning is expected to emphasize the activeness and creativity of students. The Era that takes place today is the transformation of the era from industry-based to knowledge-based, and digital transformation toward education 4.0 (Wijaya, Sudjimat, & Nyoto, 2016; Katyeudo & de Souza, 2022). The transformation era expects students to have the ability to face the problems of this century. Therefore, there is a demand for competencies that are referred to as 21st-century skills. The 2013 revised curriculum emphasizes the integration of learning with four things, namely: strengthening character education (PPK), literacy skills, 21st Century Skills (4C), and high-order thinking skills (HOTS) (Mulyasa, 2018; Setiawan et al., 2021).

Skills needed in facing the problems of the 21st century, including critical thinking skills, creative thinking, innovation, problem-solving, communication, collaboration, media literacy, ICT literacy, and the ability to live a career and life (adaptive, flexible, initiative, productive, accountability, leadership, and responsible) (Ramdani et al., 2019; Zulfiani et al., 2020). Mastery of 21st-century skills is summarized in 4C aspects, namely critical thinking, creative thinking, communication, and collaboration (Supena et al., 2021). The integration of 21st-century proficiency mastery into learning is important because it provides facilities for the holistic development of learners' abilities, digital skills, and learning discipline skills (Van Laar et al., 2020). In addition, the methods used in learning also play a role in training thinking skills in students (Zulfiani et al., 2020). In everyday life, the 4C aspect as a type of soft skill is more useful when compared to only strengthening hard skills (Darise, 2019).

Research conducted by the Global Creativity Index states the level of creativity of the Indonesian people is in position 85 out of 129 countries in the world (Wahyuni et al., 2021). The fact that the CGI index is low is evidence that learning activities have not met the learning objectives that train students' thinking skills. The ability to think creatively and problem-solving is needed by students in understanding the concept of biology lessons for environmental concepts (Sigit et al., 2019). The concept of Environmental Change has many problems that need to be solved, so it requires the ability to think and problems solving for students.

Creative thinking skills are one of the very important skills possessed by learners. The ability to think creatively is the ability to solve problems, and a logical and structured way of thinking, to produce new ideas that can solve problems (Siswati & Corebima, 2021; Susetyarini & Fauzi, 2020). Dewi Hari P. adds that in science learning such as biology, creative thinking skills are needed in facing challenges in the future (Loyens et al., 2023). Science Learning is expected to foster science process skills, critical thinking, creative thinking, and scientific attitude.

The fulfillment of learners' competencies that are integrated with 21st-century skills, especially creative thinking skills, can be obtained through meaningful learning activities. Meaningful learning arises in learning where learners experience what they learn compared to what they know (Hsbollah & Hassan, 2022). Therefore, an educator needs to apply multimethod, multistrategy, and multimedia to provide varied, meaningful, and not boring learning (Rusman, 2017). One of the factors affecting meaningfulness in learning is the selection of teaching materials. The use of teaching materials such as LKPD can provide meaningfulness in learning by providing several questions that relate the knowledge that learners have with what educators teach (Gazali, 2016).

The teaching materials generally used by schools are textbooks. Research conducted by Tivani & Paidi, (2016) shows the books provided by the government are general, so it does not reflect the characteristics of the region where students live. The exercises contained in textbooks are generally in the form of questions that are limited to understanding concepts. They lack detailed steps from 5M activities (observing, questioning, collecting information, associating, and communicating). Therefore, to support learning activities, alternative teaching materials are needed that can direct structured learning by the facts that exist around the learners.

Students' worksheets (*Lembar Kerja Peserta Didik/LKPD*) are one alternative that can be used in learning. LKPD is defined as a collection of tasks that need to be completed by students to help and facilitate students in learning activities to improve the interaction between educators and students (Panggabean & Danis, 2020). LKPD for science subjects that focus on investigation activities, data, and problems that need to be solved based on research results (Yaumi, 2018). Technological advances that occurred in recent times have also encouraged LKPD as teaching materials that are generally in the form of print into electronics. Ramlawati explained that electronic LKPD (e-LKPD) is a training sheet for students that can be done digitally, systematically, and continuously (Lathifah et al., 2021).

Arestu, Karyadi, & Ansori (2018) found that the use of LKPD in learning activities has a lack of insertion of real facts or phenomena that are close to the learners. In addition, optimization of the surrounding environmental phenomena as a source of learning adds to students' scientific insight less attention. LKPD used in schools is generally issued by publishers (Panggabean & Danis, 2020). As a result, the content of the material and the issues presented are general. Meaningful learning is obtained from content in the environment students are in. Another drawback is that the problems presented are monotonous (Lathifah et al., 2021; Panggabean & Danis, 2020).

The results of interviews with biology teachers and representatives of Class X MIPA students at SMAN A South Tangerang City showed the use of teaching materials varied, namely textbooks, teaching

modules, and LKPD. LKPD made is designed by the teacher, but LKPD is limited to questions that are general and less touching on the creative thinking skills of students. The design and presentation used by teachers in LKPD are also still simple. The results of the analysis of the suitability of LKPD made by teachers with the criteria set also only meet 3 of the 8 standard criteria set, namely: title, basic competencies, and tasks. Teachers also make less use of technology integration in the work of LKPD. This is evidenced by the technique of working on tasks that are still conventional and manual by writing in a notebook, then scanning and uploading via Google Classroom. Although teachers already use Google Classroom, the optimization of the use of digital technology is less developed.

The concept of environmental change is one aspect of study in biology. Environmental-related topics are the focus of the global world in this age. Environmental damage and pollution, as well as the increasing intensity of human activities in exploiting nature, are factors that accelerate environmental changes. The development and progress of industrialized countries account for environmental problems in developing countries (Herman & Xiang, 2022). The environment that became the study of Biology learning in this study is the environment in the area of South Tangerang city. One of the visions of South Tangerang city is to realize a green-minded city (Herlanti, 2016). The culture and habits of the people are a challenge to these ideals, namely: waste problems, lake or river ecosystems, city air, energy efficiency, and so on. Therefore, it is necessary to prepare this vision by teaching students about the urgency of the environment.

An alternative that can be used is to optimize the learning of environmental concepts that are part of Biology subjects. Environmental concepts get the focus of discussion on Permendikbud No. 24 of 2016, especially in KD 3.11 and 4.11. 3.11 basic competence to analyze data on environmental changes, their causes, and their impact on life. 4.11 basic competence formulates the idea of solving the problem of environmental changes that occur in the surrounding environment. Based on the interview results, one of the obstacles faced by students of SMAN A Kota Tangerang Selatan in this concept is the dominant mastery of basic knowledge. This is evidenced by the problems in the teacher-made LKPD, generally performed manually. The LKPD developed by the teacher did not optimize the creative thinking ability of students regarding the concept of environmental change. Therefore, alternative teaching materials are needed to train creative thinking skills on environmental change, not just mastery of basic knowledge.

Efforts to solve environmental problems and provide meaningful learning for students can be done by developing interactive e-LKPD based on creative thinking skills. Selection of the concept of environmental change by considering environmental issues that become the focus of global attention. In addition, new ideas for solving environmental problems can stimulate the creative thinking skills of students. Exercises and activities contained in the Interactive e-LKPD can direct students to a contextual problem that exists in the area of South Tangerang city. Furthermore, students are asked to solve problems by analyzing the causes, providing solutions, and designing products. Therefore, this study aims to develop an Interactive e-LKPD based on creative thinking skills on the concept of environmental change and determine the level of validity, readability, and practicality of the resulting product?

Method

This study uses the method of Developmental Research using the stages of Akker et al (2013) which consists of three stages, namely: (1) analysis, (2) design and development, and (3) evaluation (Putrawangsa, 2018). The analysis phase is carried out to find problems through the identification of needs. After doing the analysis phase, the next stage is the design and development of the resulting product in the form of prototypes I and II. The final stage after development is an evaluation to assess the validity, readability, and practicality of the Interactive e-LKPD developed. Evaluation stages refer to the evaluation proposed which consists of five stages, namely: expert assessment, person-by-person evaluation, small group evaluation, and field tests (Akker et al., 2013). The evaluation stage in this study is limited to an evaluation in small groups using students from 1 class of mathematics and natural sciences. The framework that describes the flow of Interactive e-LKPD development can be seen in Figure 1.

This study was conducted at SMAN A South Tangerang City by using a sample of 38 students from Class X MIPA 1. Data collection instruments used interview guidelines, validation questionnaire sheets, readability questionnaire sheets, and practicality questionnaire sheets. The details of the data needed in the study are shown in Table 1.

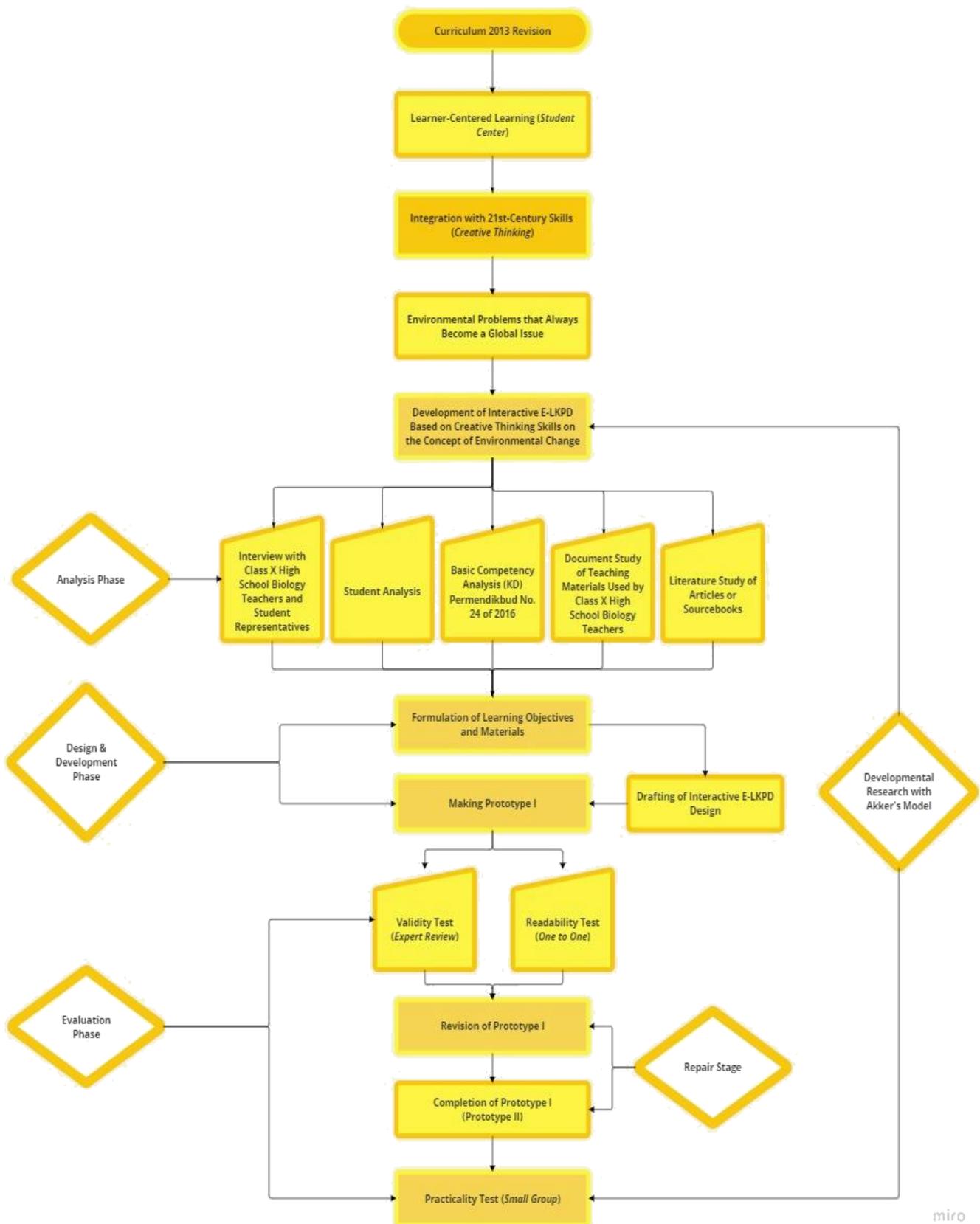


Figure 1. Framework for the development of Interactive e-LKPD on the concept of environmental change

Table 1. Description of interactive e-LKPD research needs data

Phases	Activities	Data sources	Instruments
Analysis	Identification of needs	Primary Data (Biology Teacher of X MIPA class and representatives of X MIPA class students as many as three people)	Interview guidelines
	Analysis of students	Secondary data (documents of student's grades in Biology subject)	Student's score table
	Analysis of KD	Secondary Data (Permendikbud document No. 24 of 2016)	RPP (Lesson Plan)
	Document and literature studies	Secondary Data (Depdiknas 2008 documents on making teaching materials, relevant articles and source books)	Table of completeness of LKPD components
Design and Development	Formulation of Objectives and Teaching Materials	Secondary Data (Permendikbud No. 24 of 2016 document, and Biology Learning Syllabus)	RPP (Lesson Plan)
	Drafting the Interactive E-LKPD Design	Secondary data (Biology textbook 2013 Revised Curriculum edition, internet)	Draft plan
	Making prototype I and II	Secondary data (Biology textbook 2013 Revised Curriculum edition, internet)	Interactive e-LKPD using www.liveworksheets.com
Evaluation	Validity Test	Primary Data (Expert Review of 3 people)	Validity questionnaire sheets
	Readability Test	Primary data (One to one review of 9 students)	Readability questionnaire sheets
	Practicality Test	Primary data (Biology teacher of X MIPA class as many as one person and X MIPA1 class as many as 38 people.	Practicality questionnaire sheets

The development of interactive e-LKPD based on creative thinking skills was validated by 3 experts with details of 2 experts from UIN Syarif Hidayatullah Jakarta lecturers and 1 expert from biology teacher SMAN A South Tangerang City. Validation is done in terms of material and pedagogical, as well as from aspects of design and media. As for data analysis techniques validation sheet results were performed by descriptive analysis (Formula 1) and categorized through Table 2 (Damayanti & Suniasih, 2022; Riduwan, 2015). Data analysis techniques resulting in sheet readability are also done with descriptive analysis (Formula 2) and categorized through Table 3 (Riduwan, 2015; Sabaniah et al., 2019). The technique of data analysis of the results of the practicality sheet was carried out by descriptive analysis (Formula 3) and categorized through Table 4 (Damayanti & Suniasih, 2022; Riduwan, 2015).

$$P = \frac{\sum X}{\sum Xi} \times 100\% \quad (1)$$

Where, P = Percentage of score gain, $\sum X$ = Total score gain (total score) of each item, and $\sum Xi$ = Total ideal score (highest score).

Table 2. Validity criteria

Percentage	Criteria
81 - 100	Very Valid
61 - 80	Valid
41 - 60	Quite Valid
21 - 40	Less Valid
0 - 20	Invalid

$$\text{Readability Percentage} = \frac{\text{Total score of readability sheet}}{\text{Maximum score}} \times 100\% \quad (2)$$

Table 3. Readability criteria

Percentage	Criteria
81 - 100	Very Positive
61 - 80	Positive
41 - 60	Quite Positif
21 - 40	Less Positif
0 - 20	Not Positif

$$NP = \frac{R}{SM} \times 100\% \quad (3)$$

Where, NP = Percent value, R = Total score, and SM = Maximum total score

Table 4. Practicality criteria

Percentage	Criteria
81 - 100	Very Practical
61 - 80	Practical
41 - 60	Quite Practical
21 - 40	Less Practical
0 - 20	Not Practical

In addition to calculating the results of validation tests, readability, and practicality; researchers also calculate the value of the results of LKPD work done by students to analyze creative thinking skills. The analysis technique of creative thinking skills based on the results of LKPD work is also carried out with descriptive analysis (Formula 4) and categorized through Table 5 (Arini & Asmila, 2017; Cahyani et al., 2022).

$$\text{Percentage Value Creative} = \frac{\text{Raw score obtained by the student}}{\text{Maximum score of LKPD questions}} \times 100\% \quad (4)$$

Table 5. Criteria for creative thinking skills

Percentage	Criteria
81 - 100	Very Creative
61 - 80	Creative
41 - 60	Simply Creative
21 - 40	Less Creative
0 - 20	Not Creative

Results and Discussion

Analysis phase

The analysis phase is used to determine the needs during the learning process. The results of the analysis of the use of LKPD in SMAN A South Tangerang City, namely: (1) learning activities have been using LKPD developed by teachers, but LKPD developed simple and only presents questions of a general nature, (2) LKPD used is still done conventionally, not using the integration of technology in the process, and (3) the achievement of competence has not touched on the realm of creative thinking of students. This can be seen in the presentation of LKPD questions that have just arrived at the stage of encouraging students to analyze the causes of environmental changes and evaluate solutions that can be provided in solving environmental problems. The summary of the important points of information obtained based on the results of interviews with Biology teachers and student representatives is in Table 6.

Based on the findings through the identification of needs, the LKPD used by teachers needs to be improved again in training students' creative thinking skills and optimizing the use of technology in learning. Creative thinking needs to be trained because it is included in the national education goals and is needed to face obstacles and challenges in the future (Loyens et al., 2023; Yuliani et al., 2017). The educational process in the 21st century is widely recognized as emphasizing cognitive understanding over memorization; therefore, students need to master creative thinking skills (Riadi et al., 2022). Assignments given by teachers focused on questions that were general in nature or referred to the same source book. In fact, learning must be relevant to the real world and be related to people's lives. This is because science learning materials are found and applied in people's lives (Asrizal et al., 2022). Presentation of contextual problems is considered important because it can involve the creative thinking

skills of students who will improve problem-solving skills in solving problems of environmental change (Sigit et al., 2019).

Table 6. Summary of biology teacher and students interview results

No.	Indicators	Description of Interview	
		Teacher	Students
1.	The curriculum used at SMAN A in South Tangerang City	Since the Covid-19 pandemic, learning activities have implemented the Emergency 2013 Curriculum / Pandemic version of the curriculum. However, some concepts were missed.	There is no mention of the curriculum used in the school.
2.	Biology Learning	During the pandemic, teachers find it difficult to recognize students' characteristics, network or quota constraints to hold video conferences, and difficulties in collecting students assignments. Teachers are more comfortable with offline/face-to-face learning because they can understand the students characteristics.	The challenge in online learning is to understand the material independently. Learners prefer offline/face-to-face learning because they can interact directly.
3.	Learning Media and Biology Assignment Forms	The pandemic has utilized platforms from Google, such as Google Form, Google Classroom, and Google Meet. However, the form of assignments during learning is still conventional, namely doing exercise questions by handwriting, then scanning and uploading in the form of PDF files to Google Classroom. Teachers mentioned that there had been training from the school to utilize alternative digital media.	The explanation conveyed by students is more or less the same as that provided by the teacher. Forms of assignments that have been given include practice questions, drawings, presentations, and so on.
4.	The use of LKPD in Biology Learning	The LKPD used was a simple design developed by the teacher. In addition, teaching materials are used in the form of teaching modules and source books issued by the publishers. The exercises were limited to basic knowledge of the concept of environmental change.	The average students said that teachers answered handwritten practice questions more often.
5.	Use of Online Platforms	Teachers mainly utilized Google Classrooms. Teachers have never used other platforms, such as liveworksheets.com.	Students said the same things as teachers. In fact, students who were interviewed were not familiar with the liveworksheets.com.

Technology in education has an important role because it enhances educational activities and triggers the motivation of learners, thus having innovation and skills in learning (Aslam et al., 2021; Muhasim, 2017). Therefore, the innovation that can be made in the development of LKPD involves technology. The current era has encouraged the optimization of the use of digital technology in learning, such as the internet, applications or online platforms. The use of digital technology to facilitate student learning is included in the introduction of sustainable lifestyles (Ekselsa et al., 2023). The Interactive e-LKPD that will be developed later functions as a learning company. The student worksheet, as a learning guide, functions to assist students in understanding the material and contains questions that must be answered. Furthermore, reinforcement is provided after students learn the material (Samudra & Yulkifli, 2021).

Design and development phase

The design and development phase are the stage where the formation of prototypes I and II is based on the results of the Needs Analysis. The design phase is carried out by formulating learning objectives, teaching materials, and Designing Interactive E-LKPD. At the design, stage produced a draft of the product design that will be implemented in the manufacture of Interactive E-LKPD. In addition, the planning stage is equipped with the determination of questions that will be included in the Interactive E-LKPD, interactive media selection, and color selection. The questions that are made contain things that are contextual and packaged within the framework of the stages of the creative thought process consisting of: preparation, incubation, illumination, and verification (Munandar, 2014). Creative thinking is a part of higher-order thinking that can be trained by paying attention to intuition, turning on imagination, revealing new possibilities, broadening perspectives, and generating unexpected ideas (Handayani et al., 2021). Therefore, the development of contextual questions is directed at observing events around students and solving environmental problems by generating new ideas.

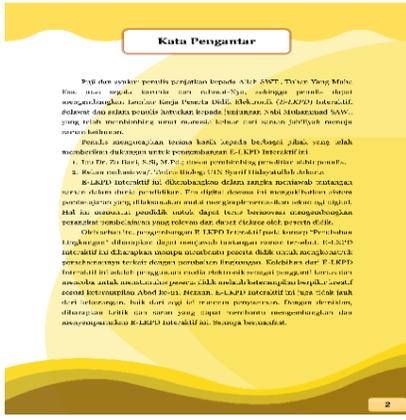
Selection of media for e-LKPD Interactive considering ease of use by users, both at school and home (Hamidah et al., 2023; Sari et al., 2022). Therefore, researchers use the web liveworksheets.com to give a real impression of working on LKPD. The website of liveworksheets.com are educational tools that allow teachers to create interactive worksheets or to search for worksheets shared by a worldwide community of teachers. Interactive worksheets were created when PDF worksheets or image files (.jpg or .png) were converted into engaging digital materials that were delivered online to students. The working principle of the Web is to combine learning activities that are only possible on a computer, thus

making interactive worksheets unique and challenging for students in an innovative way (Le & Prabjandee, 2023; Djamas et al., 2018).

The development stage is the implementation stage of the design into an interactive e-LKPD product. In the development phase obtained in the form of prototype products I and II. The composition of Interactive E-LKPD consists of three parts, namely: introduction, content, and closing. The results of the development of prototype I were then evaluated in the form of validation tests by experts and readability tests by representatives of Class X MIPA students as many as 9 people. Furthermore, various suggestions were obtained from the validation and readability test results of the prototype I made revisions to the prototype I produced by the product in the form of prototype II.

Broadly speaking, Interactive E-LKPD is divided into three main parts, namely: introduction, content, and closing. The introduction section of the Interactive E-LKPD before and after the revision is shown in the following Table 7.

Table 7. Comparison of the introduction section of prototype i (before revision) and prototype ii (after revision)

Components	Before revision	After revision
Cover (title, UIN Jakarta logo, students identity, class, semester, curriculum, researcher name, supervisor, and researcher institution)		
Preface		

Components
Before revision
After revision

Table of contents

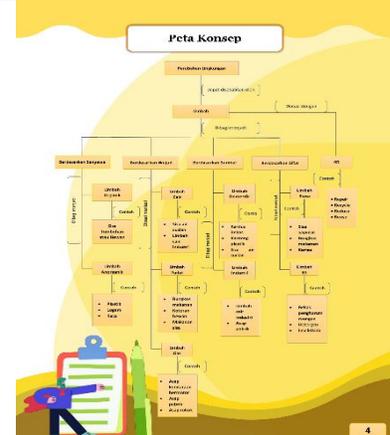
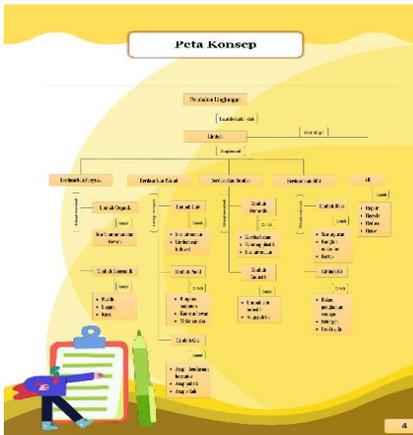
Daftar Isi

Cover	1
Kata Pengantar	2
Daftar Isi	3
Peta Konsep	4
Kompetensi Inti (KI)	5
Kompetensi Dasar (KD)	6
Indikator Pencapaian Kompetensi (IPK)	7
Petunjuk Penggunaan LKPD	8
Materi Pokok	9
Pembelajaran	10
Evaluasi	12
Verifikasi	13
Daftar Pustaka	15

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Evaluasi	12
Verifikasi	13
Daftar Pustaka	15

Concept map



Section contains core competencies, basic competencies, and indicators of achievement of competence

KI, KD, & IPK

Kompetensi Inti (KI)	
KI-1 (Sikap Spiritual)	Menyadari dan mengamalkan ajaran agama yang dianutnya. Menghormati dan menghormati perbedaan agama, ras, suku, bangsa, golongan, gender, dan kemampuan fisik, serta menghormati hak-hak orang lain.
KI-2 (Sikap Sosial)	Menghargai dan menghayati ajaran agama yang dianutnya. Menghormati dan menghormati perbedaan agama, ras, suku, bangsa, golongan, gender, dan kemampuan fisik, serta menghormati hak-hak orang lain.
KI-3 (Pengetahuan)	Memahami, menerapkan, menganalisis pengetahuan faktual, konseptual, prosedural berdasarkan rasa ingintahunya tentang ilmu pengetahuan, teknologi, seni, budaya, dan humaniora dengan wawasan kemanusiaan, kebangsaan, kenegaraan, dan peradaban terkait penyebab fenomena dan kejadian, serta menerapkan pengetahuan prosedural pada tingkat kelas yang spesifik sesuai dengan bakat dan minatnya untuk memecahkan masalah.
KI-4 (Keterampilan)	Mengolah, menalar, dan menyaji dalam ranah konkret dan ranah abstrak terkait dengan pengembangan dari yang dipelajarinya di sekolah secara mandiri, dan mampu menggunakan metoda sesuai kaidah keilmuan.

Kompetensi Dasar	Indikator Pencapaian Kompetensi
3.11 Menganalisis data perubahan lingkungan, penyebab, dan dampaknya bagi keberagaman hayati	<ul style="list-style-type: none"> Mengukur debit air limbah Menganalisis kualitas air limbah Menganalisis dampak limbah terhadap lingkungan hayati
4.11 Merencanakan pemecahan masalah perubahan lingkungan yang terjadi di lingkungan sekitar	<ul style="list-style-type: none"> Merencanakan solusi pemecahan limbah yang ada di lingkungan sekitar Mendiskusikan masalah saat ini dan masalah limbah

KI, KD, & IPK

Kompetensi Inti (KI)	
KI-1 (Sikap Spiritual)	Menghargai dan menghayati ajaran agama yang dianutnya. Menghormati dan menghormati perbedaan agama, ras, suku, bangsa, golongan, gender, dan kemampuan fisik, serta menghormati hak-hak orang lain.
KI-2 (Sikap Sosial)	Menghargai dan menghayati ajaran agama yang dianutnya. Menghormati dan menghormati perbedaan agama, ras, suku, bangsa, golongan, gender, dan kemampuan fisik, serta menghormati hak-hak orang lain.
KI-3 (Pengetahuan)	Memahami, menerapkan, menganalisis pengetahuan faktual, konseptual, prosedural berdasarkan rasa ingintahunya tentang ilmu pengetahuan, teknologi, seni, budaya, dan humaniora dengan wawasan kemanusiaan, kebangsaan, kenegaraan, dan peradaban terkait penyebab fenomena dan kejadian, serta menerapkan pengetahuan prosedural pada tingkat kelas yang spesifik sesuai dengan bakat dan minatnya untuk memecahkan masalah.
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Mengembangkan Dasar	Indikator Pencapaian Kompetensi
3.11 Menganalisis data perubahan lingkungan, penyebab, dan dampaknya bagi keberagaman hayati	<ul style="list-style-type: none"> Mengukur debit air limbah Menganalisis kualitas air limbah Menganalisis dampak limbah terhadap lingkungan hayati
4.11 Merencanakan pemecahan masalah perubahan lingkungan yang terjadi di lingkungan sekitar	<ul style="list-style-type: none"> Merencanakan solusi pemecahan limbah yang ada di lingkungan sekitar Mendiskusikan masalah saat ini dan masalah limbah

Components
Before revision
After revision

Guide to the use of Interactive E-LKPD



The table above shows the differences between Prototypes I and II. Prototype I is the product before revision, and Prototype II is the product after revision. The most identical differences can be seen in several parts before and after the revision. The cover includes additional sentence editorials and layout improvements. On the concept map, there was a change from portrait to landscape page proportion. In addition, the instructions for use after revision are differentiated for teachers and students, and the LKPD work limits are given in this section.

The contents of the Interactive E-LKPD contain issues that need to be done by students. The presentation of the questions uses the framework of the stages of the creative thought process which consists of four steps, namely: preparation, incubation, illumination, and verification. The closing section of the Interactive E-LKPD contains references used in the preparation of the LKPD. The contents and cover of the Interactive E-LKPD before and after revision are shown in the following **Table 8**.

Table 8. Comparison of the content and cover sections of prototype I (before revision) and prototype II (after revision)

Components
Before revision
After revision

The subject matter which contains a summary of the material related to the concept of environmental change



Verification stage, students are asked to make a draft of the idea/idea of one of the solutions given in the illumination stage

Verifikasi

Buatlah skema rancangan produk yang dapat membantu menyelesaikan permasalahan lingkungan akibat limbah sampah dan tuliskan pada lembar di bawah ini! Adapun komponen yang perlu dituliskan, yaitu:

1. Deskripsi singkat rancangan produk yang akan dibuat (*ceklaskan tidak menggunakan istilah ilmiah/istilah biologi*)
2. Alat dan bahan yang digunakan
3. Langkah kerja
4. Skema/desain sederhana dari rancangan produk yang akan dibuat (*diisi dengan gambar/ gambar desain/diagram/ foto produk, sehingga dapat dipahami link google drive, atau lampirkan di LKPD ini*)

Verifikasi

Buatlah skema rancangan produk yang dapat membantu menyelesaikan permasalahan lingkungan akibat limbah sampah dan tuliskan pada lembar di bawah ini! Adapun komponen yang perlu dituliskan, yaitu:

1. Deskripsi singkat rancangan produk yang akan dibuat (*ceklaskan tidak menggunakan istilah ilmiah/istilah biologi*)
2. Alat dan bahan yang digunakan
3. Langkah kerja
4. Skema/desain sederhana dari rancangan produk yang akan dibuat (*diisi dengan gambar/ gambar desain/diagram/ foto produk, sehingga dapat dipahami link google drive, atau lampirkan di LKPD ini*)

Bibliography.

Daftar Pustaka

Pratiwi, Dwi, dkk. 2021. *Lingkungan Beracun*. CV. Media Sains Indonesia.

Rahman, Umar. 2014. *Biologi 2: Untuk Kelas X Sekolah Menengah Atas/Kelas Permulaan Mahasiswa dan Ilmu Biologi*. Bandung: Grafindo Media Pratama.

Mardiah, A. 2018. *Sejarah Pengabdian Masyarakat di Kota Tangerang Selatan*. *Jurnal Pendidikan*, Vol. 2, No.1, hal. 145 – 150.

Baharwan, Rida, dkk. 2020. *Buku Siswa Biologi untuk SMA/MA Kelas X*. Kemdikbud, Jakarta.

https://www.researchgate.net/publication/354914167/figure/fig/1/figure-fig1/354914167/figure.png?at_medium=original&at_source=pubmed&at_campaign=share&at_medium=original&at_source=pubmed&at_campaign=share

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Daftar Pustaka

Pratiwi, Dwi, dkk. 2021. *Lingkungan Beracun*. CV. Media Sains Indonesia.

Rahman, Umar. 2014. *Biologi 2: Untuk Kelas X Sekolah Menengah Atas/Kelas Permulaan Mahasiswa dan Ilmu Biologi*. Bandung: Grafindo Media Pratama.

Mardiah, A. 2018. *Sejarah Pengabdian Masyarakat di Kota Tangerang Selatan*. *Jurnal Pendidikan*, Vol. 2, No.1, hal. 145 – 150.

Baharwan, Rida, dkk. 2020. *Buku Siswa Biologi untuk SMA/MA Kelas X*. Kemdikbud, Jakarta.

https://www.researchgate.net/publication/354914167/figure/fig/1/figure-fig1/354914167/figure.png?at_medium=original&at_source=pubmed&at_campaign=share&at_medium=original&at_source=pubmed&at_campaign=share

Abstrak pada tanggal 21 Februari 2022 pukul 15:43 WIB.

In the content and closing sections, there were differences before and after revision. In the preparation stage, questions that reflect students' understanding of the subject matter are added in the initial section. Furthermore, an article on the environmental problems that occur in South Tangerang City is presented. In addition, the writing of the question instructions was made in the form of bullet points to make it easier for students to understand the purpose of the question. This applies to other parts of the question. The use of terms was also adjusted to make it easier for learners to understand the purpose of the question, for example the use of the word "problematic" to become "problem." Another improvement after revision is the arrangement of writing and space on the Interactive E-LKPD to make it appear more proportional.

Evaluation phase

The evaluation phase used the evaluation of Tessmer (1993) which consists of expert assessment, person-by-person test, small group test, and field test. Assessment of e-LKPD Interactive to see the level of validity, readability, and practicality. The validity test conducted by 3 experts resulted in the percentage of the average value listed in Table 9. The validation carried out by experts includes material and pedagogical aspects, as well as design and media aspects.

Table 9. Interactive e-LKPD validation result details

Validator	Validation	Assessment aspects	Rating result (%)	Categories	Average rating result (%)	Final category
1	Design and Media	Graphics	87.50	Very Valid	87.50	Very Valid
		Language	75.00	Valid		
		Presentation	100	Very Valid		
2	Material and Pedagogic	Content Eligibility	93.75	Very Valid	91.49	Very Valid
		Language	75.00	Valid		
		Presentation	100	Very Valid		
		Pedagogy	97.22	Very Valid		
3	Material and Pedagogic	Content Eligibility	100	Very Valid	93.75	Very Valid

Language	75.00	Valid
Presentation	100	Very Valid
Pedagogy	100	Very Valid

The average percentage of overall validation results can be seen in [Table 10](#). The validation results determine the feasibility of Interactive e-LKPD for use in learning the biology of environmental change concepts.

Table 10. The final description of the validation result of interactive e-LKPD

Validation	Validator	Rating result (%)	Average rating result (%)	Average final assessment result (%)	Criteria
Design and Media	1	87.50	87.50	90.06	Very Valid
Material and	1	91.49	92.62		
Pedagogy	2	93.75			

Based on the results of the final validation can be categorized as very valid because it obtained the final average value of 90.06%. The interactive E-LKPD developed has fulfilled the didactic, construction, technical, and pedagogical requirements ([Diana et al., 2020](#); [Kosasih, 2021](#); [Nana, 2020](#)). The term didactics is evidenced by the use of varied media and activities, as well as the developing learners through learning experiences. The term construction is evidenced by the use of clear language and provides creative thinking space for learners. Technical requirements are evidenced by the use of writing, images, and appearance used in e-LKPD Interactive. The term pedagogic is evidenced by the process of discovery of concepts that are part of this interactive e-LKPD. This indicates that Interactive e-LKPD can be used in learning activities. In addition, the developed interactive e-LKPD belongs to the category of feasible for use based on the general view given by experts.

After going through the validity test, the next stage is to see the readability of Interactive e-LKPD through testing person by person. The readability test serves to see if LKPD is good and can be used in learning ([Uniati et al., 2019](#)). The results of the interactive e-LKPD readability test can be seen in [Table 11](#).

Table 11. The final description of the interactive e-LKPD readability test result

Assessment aspects	Rating results (%)	Categories	Average final assessment result (%)	Criteria
View	83.34	Very Positive	94.91	Very Positive
Text Clarity	96.30	Very Positive		
Presentation	100	Very Positive		
LKPD Uses	100	Very Positive		

The readability test results obtained a final average value of 94.91% with a very positive category. This indicates that e-LKPD Interactive has excellent readability. The final stage of the evaluation of this study is a practical test of Interactive e-LKPD developed. The results of the interactive e-LKPD practicality test can be seen in [Table 12](#).

Table 12. The final description of the Interactive e-LKPD practicality test result

Respondent	Assessment aspects	Rating result (%)	Categories	Average rating result (%)
Teacher	View & Presentation	100	Very Practical	100
	Language	100	Very Practical	
	Content Suitability	100	Very Practical	
	Practicality	100	Very Practical	
Learners	View & Presentation	80,67	Very Practical	81,22
	Language	84,43	Very Practical	
	Content Suitability	80,59	Practical	
	Practicality	79,17	Practical	

The results of the practical test obtained an average value of 100% from the teacher with a very practical

category, while the average value of the students was 81.22% with a very practical category. Considerations in the practicality of the reference are the time required in the use of artificial instruments, including: fast, short, and precise (Lestari et al., 2018; Tanu et al., 2022). This interactive E-LKPD allows students to directly work on LKPD directly and connected to the internet, so there is no need to work conventionally. This indicates that e-LKPD Interactive has a very good level of practicality.

The Interactive e-LKPD developed after three stages of testing has very valid, very positive, and efficient criteria. It proves that interactive e-LKPDs can be an alternative to learning activities. Integrating technology in student worksheets can also train students' creative thinking skills. Other similar studies developing student worksheets assisted by online software, such as PhET, were declared valid and practical in research-based learning to improve the creative thinking skills of high school students (Chotimah & Festiyed, 2021). Developing interactive e-LKPDs based on creative thinking skills can improve students' creativity.

LKPD used by teachers in learning is still focused on the analysis of environmental problems so learning is expected to train creative thinking skills has not been fully implemented. Therefore, it is necessary for LKPD that can train the creative thinking skills of students. The results of creative thinking skills in students based on the results of the interactive e-LKPD can be seen in Table 13.

Table 13. Recapitulation of the value of creative thinking skills e-LKPD interactive

Trial	Creative thinking skills	Rating result (%)	Average final assessment result (%)	Final criteria
Person per person (9 students)	Fluency	91.11	90	Very Creative
	Flexibility	88.89		
	Originality	88.89		
	Elaboration	91.11		
Small group (38 Students)	Fluency	74.74	80.65	Creative
	Flexibility	74.21		
	Originality	85.26		
	Elaboration	88.95		

The ability to think creatively on the readability and practicality test obtained different results. Creative thinking skills based on the results of the literacy test obtained an average value of 90 with a very creative category; while, creative thinking skills based on the results of the practicality test obtained an average value of 80.65 with a creative category. This difference is also seen in the characteristics of creative thinking skills. The results of the readability test showed that the highest aspect was in the aspect of thinking fluently (fluency) and the ability to elaborate ideas (elaboration); meanwhile, the lowest aspect is found in the aspect of flexible thinking (flexibility) and original thinking (originality). The results of the practical test showed that the highest aspect was in the aspect of original thinking and the ability to elaborate ideas; while, the lowest aspect was found in the aspect of thinking fluently and thinking flexibly.

Aspects of thinking fluently (fluency) in the Interactive e-LKPD in the form of questions that ask students to provide answers and solutions to environmental problems. The aspect of thinking fluently emphasizes the ability of students to generate ideas as much as possible. This is because this aspect focuses on quantity, not quality (Sabaniah et al., 2019). This aspect gets high results in the readability test sample because the answer options and solutions to environmental problems are more than in the practical test sample.

Aspects of flexible thinking (flexibility) in the Interactive e-LKPD in the form of questions that ask students to provide answers to various problem-solving. This aspect is a low part of the results of both Tests because students are mostly only able to give a lot of answers in terms of quantity, but do not give arguments related to the choice of answers. This is related to the characteristics of flexible thinking aspects that encourage students to provide arguments about the cause and effect of a problem (Maker et al., 2023; Sabaniah et al., 2019).

The aspects of fluency thinking with flexible thinking show a close percentage, although a lower percentage is found in the aspect of flexible thinking. This is because, at the flexibility level, someone has difficulty solving the problem properly. Someone in this category will try to find answers without difficulty. Emotional barriers can be one of the factors that hinder creative thinking skills, and are seen as barriers to creativity, such as lack of tolerance and excessive self-criticism (Nurhamidah et al., 2018).

Aspects of original thinking (originality) in the Interactive e-LKPD in the form of questions that ask students to provide different solutions between students and implemented them in product design. The results of the students' answers on the aspect of original thinking there are still the same answers among other students. However, there are also students' answers in the form of ideas that are not necessarily thought of by everyone. For example, make a garbage exchange machine with money or make bubble wrap from natural materials. This aspect also encourages learners to elaborate on ideas in detail (Sabaniah et al., 2019). Therefore, students are asked to create a product design to provide an overview

of related products that can help solve environmental problems, although in the end students are not required to make the product physically. The percentage of this aspect was greater than that of thinking fluently and flexibly. This indicates that students are sensitive and concerned about everyday problems. (Loyens et al., 2023) explained that broad knowledge forms the basis of creativity. Thus, the broader one's knowledge, the wider the opportunity to create new ideas and provide authentic solutions to problems (Nurhamidah et al., 2018).

Aspects of the ability to elaborate ideas (elaboration) on Interactive e-LKPD encourage students to detail the ideas that will be made in product design. This aspect requires learners to elaborate on an idea or ideas in detail or detail (Sabaniah et al., 2019; Yuliani et al., 2017). The results of students' answers in both samples look like students can detail the design of the product they will make. Details are given by the instructions starting from the description of the product design, tools, materials, and work steps, as well as the design of the product design. However, in some students, there are incomplete answers that can affect the assessment of this aspect. The percentage of this aspect was greater than those of the three previous aspects. Someone with good elaboration skills tends to be able to solve problems systematically and orderly, providing more details and explanations (Nasution et al., 2023; Nurhamidah et al., 2018).

The results of the acquisition of varied values are due to many factors and habits, for example, limited information obtained by students to limit their creativity, Creativity can be interpreted as cognitive skills that can provide solutions to problems (Pratomo et al., 2021; Sigit et al., 2019). In addition, students who are less open to new experiences, have less mastery of concepts, and limited time can also result in less optimal learning (Yuliani et al., 2017). Another factor that can also affect the limited ability to think creatively is the lack of search for learning resources that encourage critical thinking (Nasution et al., 2023). The ability to think creatively can still be developed, so there are many alternatives to practice this ability. One of them is the use of electronic LKPD which can facilitate the use, practical, and features that make it more attractive (Sari et al., 2022).

This Interactive e-LKPD has strengths and limitations in its application. The strength of Interactive e-LKPD using liveworksheets.com web is that it can be accessed both during learning in class and outside of class. The difference between conventional learning and e-LKPD is in terms of interaction, where conventional learning requires direct interaction in class, whereas e-LKPD makes it easy to access whenever and wherever students are. In addition, the use of Interactive e-LKPD also saves the use of paper, thus helping balance the environment.

The limitations of the Interactive e-LKPD based on the research results are the limitations of the existing system in presenting tools that provide opportunities for students to adjust the font type, font color, font size, and paragraph alignment settings. Although this Interactive e-LKPD uses the web, it requires users to create an account first. In addition, the display of Interactive e-LKPD using a liveworksheet.com web is more comfortable when using a laptop or computer than when using a cellphone. This is because it affects the size of the screen that will be viewed by the user.

Conclusion

The results of the study showed excellent results when viewed from the test results validity, readability, and practicality. The validity test results of the three validators obtained an average value of 90.06% with a very valid category. Readability test results from representatives of nine students of Class X MIPA obtained an average value of 94.91% with a very positive category. The results of the practical test of biology teachers and students of Class X MIPA 1 each obtained a value of 100% and 81.22% with a very practical category. Based on the research shows the acquisition of the average value of the class to work on Interactive E-LKPD gets a value of 81.95 with mastery of creative thinking skills obtaining an average value of 80.65 in the creative category. The development of Interactive e-LKPD can train students' creative thinking skills. This is because the questions presented construct the understanding of students associated with everyday problems are contextual. In addition, integrating LKPD with digital technology can provide meaningful learning for students.

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Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

Author Contributions

R. Ardiansah: conceptualization, methodology, design, analysis, writing – original draft preparation, review, and editing. **Zulfiani:** analysis, evaluation, writing – original draft preparation, review, and editing.

References

- Akker, J. van den, Bannan, B., Kelly, A. E., Nieveen, N., & Plomp, T. (2013). Educational design research. In T. Plomp & N. Nieveen (Eds.), *Educational Design Research*. Netherlands Institute for Curriculum Development (SLO). <https://slo.nl/publish/pages/2904/educational-design-research-part-a.pdf>
- Arestu, O. O., Karyadi, B., & Ansori, I. (2018). Peningkatan kemampuan memecahkan masalah melalui lembar kegiatan peserta didik (LKPD) berbasis masalah. *Diklabio: Jurnal Pendidikan Dan Pembelajaran Biologi*, 2(2), 58–66. <https://doi.org/10.33369/diklabio.2.2.58-66>
- Arini, W., & Asmila, A. (2017). Analisis kemampuan berpikir kreatif pada materi cahaya siswa kelas VIII SMP Xaverius Kota Lubuklinggau. *Science and Physics Education Journal (SPEJ)*, 1(1), 23–38. <https://doi.org/10.31539/spej.v1i1.41>
- Aslam, M., Azis, A. A., & Adnan, A. (2021). Pengembangan E-LKPD berbasis SALINGTEMAS (sains, lingkungan, teknologi, masyarakat) materi perubahan lingkungan kelas X SMA. *Jurnal Biotek*, 9(2), 224–243. <https://doi.org/10.24252/jb.v9i2.25885>
- Asrizal, Yurnetti, & Usman, E. A. (2022). Ict thematic science teaching material With 5E learning cycle model To develop students' 21st-century skills. *Jurnal Pendidikan IPA Indonesia*, 11(1), 61–72. <https://doi.org/10.15294/jpii.v11i1.33764>
- Cahyani, E. R., Martini, & Purnomo, A. R. (2022). Analisis kemampuan berpikir kreatif siswa SMP terhadap konsep pencemaran lingkungan ditinjau dari perbedaan gender. *Pensa E-Jurnal : Pendidikan Sains*, 10(1), 8–15. <https://ejournal.unesa.ac.id/index.php/pensa/article/view/41109>
- Chotimah, C., & Festiyed. (2021). Validity and practicality of worksheet assisted by PhET interactive simulations to improve students creative thinking skills in a research based learning model. *Journal of Physics: Conference Series*, 1876(1), 1–5. <https://doi.org/10.1088/1742-6596/1876/1/012060>
- Damayanti, M. S. D., & Suniasih, N. W. (2022). Lembar kerja peserta didik (LKPD) interaktif materi IPA sistem pernapasan manusia. *Journal for Lesson and Learning Studies*, 5(1), 10–18. <https://doi.org/10.23887/jlls.v5i1.45261>
- Darise, G. N. (2019). Implementasi kurikulum 2013 revisi sebagai solusi alternatif pendidikan di Indonesia dalam menghadapi revolusi industri 4.0. *Jurnal Ilmiah Iqra'*, 13(2), 41–53. <https://doi.org/10.30984/jii.v13i2.967>
- Darwis, A., Yendra, R., & Marizal, M. (2022). Evaluation of the curriculum of Junior High School mathematics subject using spatial analysis in the Regions of Pekanbaru. *International Journal of Educational Methodology*, 8(2), 231–240. <https://doi.org/10.12973/ijem.8.2.231>
- Diana, R., Aprilia, A. A., Curnitasari, A., & Nana, N. (2020). Correlation between voltage concepts and daily life activities using POE2WE model as character education reinforcement. *Jurnal Pendidikan Fisika*, 8(2), 155–162. <https://doi.org/10.26618/jpf.v8i2.3301>
- Djamas, D., Tinedi, V., & Yohandri. (2018). Development of interactive multimedia learning materials for improving critical thinking skills. *International Journal of Information and Communication Technology Education*, 14(4), 66–84. <https://doi.org/10.4018/IJCTE.2018100105>
- Ekselsa, R. A., Purwianingsih, W., Anggraeni, S., & Wicaksono, A. G. C. (2023). Developing system thinking skills through project-based learning loaded with education for sustainable development. *JPBI (Jurnal Pendidikan Biologi Indonesia)*, 9(1), 62–73. <https://doi.org/10.22219/jpbi.v9i1.24261>
- Fuhse, J. A. (2022). How can theories represent social phenomena? *Sociological Theory*, 40(2), 99–123. <https://doi.org/10.1177/07352751221087719>
- Gazali, R. Y. (2016). Pengembangan bahan ajar matematika untuk siswa SMP berdasarkan teori belajar ausubel. *PYTHAGORAS: Jurnal Pendidikan Matematika*, 11(2), 182–192. <https://doi.org/10.21831/pg.v11i2.10644>
- Le, V. H.H., & Prabjandee, D. (2023). A review of the website liveworksheets.com. *Call-Ej*, 24(1), 269–279. <http://callej.org/journal/24-1/Le-Prabjandee2023.pdf>
- Hamidah, A., Ayunasari, D. S., & Sanjaya, E. (2023). Development of E-LKPD in motion system materials for High School class using pageflip 3D software. *Jurnal Penelitian Pendidikan IPA*, 9(3), 1233–1241. <https://doi.org/10.29303/jppipa.v9i3.3396>
- Handayani, S. A., Rahayu, Y. S., & Agustini, R. (2021). Students' creative thinking skills in biology learning: Fluency, flexibility, originality, and elaboration. *Journal of Physics: Conference Series*,

- 1747(1). <https://doi.org/10.1088/1742-6596/1747/1/012040>
- Herlanti, Y. (2016). Pengembangan kurikulum pendidikan lingkungan di Kota Tangerang Selatan: Bagaimana mengintegrasikan deklarasi tbilisi dalam kurikulum. *Journal Proceeding Biology Education Conference: Biology, Science, Enviromental, and Learning*, 13(1), 52–57. <https://jurnal.uns.ac.id/prosbi/article/view/5650>
- Herman, K. S., & Xiang, J. (2022). How collaboration with G7 countries drives environmental technology innovation in ten Newly Industrializing Countries. *Energy for Sustainable Development*, 71, 176–185. <https://doi.org/10.1016/j.esd.2022.09.011>
- Hsbollah, H. M., & Hassan, H. (2022). Creating meaningful learning experiences with active, fun, and technology elements in the problem-based learning Approach and its implications. *Malaysian Journal of Learning and Instruction*, 19(1), 147–181. <https://doi.org/10.32890/mjli2022.19.1.6>
- Katyeudo, K. K., & de Souza, R. A. C. (2022). Digital transformation towards education 4.0. *Informatics in Education*, 21(2), 283–309. <https://doi.org/10.15388/infedu.2022.13>
- Kosasih, E. (2021). *Pengembangan bahan ajar* (B. S. Fatmawati (ed.)). Bumi Aksara. https://scholar.google.co.id/scholar?hl=en&as_sdt=0%2C5&as_vis=1&q=Kosasih%2C+E.+%282021%29.+Pengembangan+Bahan+Ajar+%28B.+S.+Fatmawati+%28ed.%29%29.+Bumi+Aksara.&btnG=
- Lathifah, M. F., Hidayati, B. N., & Zulandri. (2021). Efektifitas LKPD elektronik sebagai media pembelajaran pada Masa pandemi Covid-19 untuk guru di YPI bidayatul hidayah Ampenan. *Jurnal Pengabdian Magister Pendidikan IPA*, 4(2), 25–30. <https://doi.org/10.29303/jpmipi.v3i2.668>
- Lestari, L., Alberida, H., & Rahmi, Y. L. (2018). Validitas dan praktikalitas lembar kerja peserta didik (LKPD) materi kingdom plantae berbasis pendekatan saintifik untuk peserta didik kelas X SMA/MA. *Jurnal Eksakta Pendidikan (Jep)*, 2(2), 170–177. <https://doi.org/10.24036/jep/vol2-iss2/245>
- Loyens, S. M. M., van Meerten, J. E., Schaap, L., & Wijnia, L. (2023). Situating higher-order, critical, and critical-analytic thinking in problem-and project-based learning environments: A systematic review. In *Educational Psychology Review* (Vol. 35, Issue 2). Springer US. <https://doi.org/10.1007/s10648-023-09757-x>
- Maker, C. J., Bahar, A. K., Pease, R., & Alfaiz, F. S. (2023). Discovering and nurturing creative problem solving in young children: An exploratory study. *Journal of Creativity*, 33(2), 100053. <https://doi.org/10.1016/j.yjoc.2023.100053>
- Muhasim. (2017). Pengaruh tehnologi digital terhadap motivasi belajar peserta didik. *Palapa: Jurnal Studi Keislaman Dan Ilmu Pendidikan*, 5(2), 53–77. <https://doi.org/10.36088/palapa.v5i2.46>
- Mulyasa, H. E. (2018). *Implementasi kurikulum 2013 revisi: dalam era Industri 4.0* (B. S. Fatmawati (ed.)). Bumi Aksara. https://scholar.google.com/scholar?hl=en&as_sdt=0%2C5&q=Implementasi+Kurikulum+2013+Revisi%3A+Dalam+Era+Industri+4.0&btnG=
- Munandar, S. C. U. (2014). *Kreativitas & keberbakatan: Strategi mewujudkan potensi kreatif & bakat*. PT. Gramedia Pustaka Utama. <https://www.semanticscholar.org/author/S.-Munandar/119361408>
- Nana, N. (2020). Pengembangan inovasi modul digital dengan model POE2WE sebagai salah satu alternatif pembelajaran daring di masa new normal. *Prosiding SNFA (Seminar Nasional Fisika Dan Aplikasinya)*, 5, 167–176. <https://doi.org/10.20961/prosidingsnfa.v5i0.46607>
- Nasution, N. E. A., Al Muhdhar, M. H. I., Sari, M. S., & Balqis. (2023). Relationship between critical and creative thinking skills and learning achievement in biology with reference to educational level and gender. *Journal of Turkish Science Education*, 20(1), 66–83. <https://doi.org/10.36681/tused.2023.005>
- Nurhamidah, D., Masykuri, M., & Dwiastuti, S. (2018). Profile of senior high school students' creative thinking skills on biology material in low, medium, and high academic perspective. *Journal of Physics: Conference Series*, 1006(1). <https://doi.org/10.1088/1742-6596/1006/1/012035>
- Panggabean, N. H., & Danis, A. (2020). *Desain pengembangan bahan ajar berbasis sains* (J. Simarmata (ed.)). Yayasan Kita Menulis. https://scholar.google.com/citations?view_op=view_citation&hl=id&user=zL0wciAAAAAJ&citation_for_view=zL0wciAAAAAJ:9yKSN-GCB0IC
- Pratomo, L. C., Siswandari, & Wardani, D. K. (2021). The effectiveness of design thinking in improving student creativity skills and entrepreneurial alertness. *International Journal of Instruction*, 14(4), 695–712. <https://doi.org/10.29333/iji.2021.14440a>
- Putrawangsa, S. (2018). Desain pembelajaran: Design research sebagai pendekatan desain pembelajaran. In U. Hasanah (Ed.), *Cv. Reka Karya Amerta* (1st ed., Issue April). CV. Reka Karya Amerta. https://scholar.google.co.id/scholar?hl=en&as_sdt=0%2C5&as_vis=1&q=Putrawangsa%2C+S.+%282018%29.+Desain+Pembelajaran%3A+Design+Research+sebagai+Pendekatan+Desain+Pembelajaran.+In+U.+Hasanah+%28Ed.%29%2C+Cv.+Reka+Karya+Amerta+%281st+ed.%2C+Issue+April%29.+

- Rahmat, P. S. (2021). *Landasan pendidikan*. SCOPINDO MEDIA PUSTAKA. https://scholar.google.co.id/citations?view_op=view_citation&hl=en&user=-qTGzYYAAAAAJ&citation_for_view=-qTGzYYAAAAAJ:L8Ckcad2t8MC
- Ramdani, A., Jufri, A. W., Gunawan, G., Hadisaputra, S., & Zulkifli, L. (2019). Pengembangan alat evaluasi pembelajaran IPA yang mendukung keterampilan abad 21. *Jurnal Penelitian Pendidikan IPA*, 5(1), 98–108. <https://doi.org/10.29303/jppipa.v5i1.221>
- Riadi, B., Perdana, R., Prasetya, R. A., & Prayogi, R. (2022). The empowerment of critical and creative thinking (CCT) skills in Indonesian language learning: A case study of online learning in secondary school during the COVID-19 pandemic. *Proceedings of the Universitas Lampung International Conference on Social Sciences (ULICoSS 2021)*, 628(ULICoSS 2021), 85–90. <https://doi.org/10.2991/assehr.k.220102.011>
- Riduwan. (2015). *Skala pengukuran variabel-variabel penelitian* (J. S. Husdarta, A. Rusyana, & Enas (eds.)). Alfabeta. https://scholar.google.com/scholar?hl=en&as_sdt=0%2C5&q=Riduwan.+%282015%29.+Skala+Pengukuran+Variabel+Penelitian+%28J.+S.+Husdarta%2C+A.+Rusyana%2C+%26+Enas+%28eds.%29%29.+Alfabeta.&btnG=
- Rusman. (2017). *Belajar dan pembelajaran: berorientasi standar proses pendidikan*. Prenada Media. https://scholar.google.co.id/scholar?q=Rusman.+2017.+Belajar+dan+Pembelajaran:+Berorientasi+Standar+Proses+Pendidikan.+Prenada+Media.&hl=en&as_sdt=0&as_vis=1&oi=scholar
- Sabaniah, N., Winarni, E. W., & Jumiarni, D. (2019). Peningkatan kemampuan berpikir kreatif melalui lembar kerja peserta didik (LKPD) berbasis creative problem solving. *Diklabio: Jurnal Pendidikan Dan Pembelajaran Biologi*, 3(2), 230–239. <https://doi.org/10.33369/diklabio.3.2.230-239>
- Samudra, E. Y. A., & Yulkifli, Y. (2021). Validity of interactive student worksheets based on inquiry based learning models to improve knowledge competence. *Journal of Physics: Conference Series*, 1876(1), 1–7. <https://doi.org/10.1088/1742-6596/1876/1/012033>
- Sari, W. R., Putri, A. N., & Murhartati, E. (2022). Pengembangan e-worksheet berbasis problem based Learning terintegrasi STEM pada materi sistem peredaran darah Kelas XI SMA. (*JPB*) *Jurnal Pembelajaran Biologi: Kajian Biologi Dan Pembelajarannya*, 9(1), 13–21. <https://ejournal.unsri.ac.id/index.php/fpb/article/view/16594/pdf>
- Setiawan, J., Sudrajat, A., Aman, & Kumalasari, D. (2021). Development of higher order thinking skill assessment instruments in learning Indonesian history. *International Journal of Evaluation and Research in Education*, 10(2), 545–552. <https://doi.org/10.11591/ijere.v10i2.20796>
- Sigit, D. V., Heryanti, E., Pangestika, D. A. W., & Ichsan, I. Z. (2019). Pembelajaran lingkungan bagi siswa: Hubungan kemampuan berpikir kreatif dengan kemampuan pemecahan masalah. *Jurnal Pendidikan: Teori, Penelitian, Dan Pengembangan*, 4(1), 6–12. <https://doi.org/10.17977/jptpp.v4i1.11838>
- Siswati, B. H., & Corebima, A. D. (2021). *Pembelajaran IPA & Biologi di Indonesia (belum memberdayakan keterampilan berpikir)*. PT Teguh Ikhyak Properti Seduluran (Penerbit TIPS). [https://scholar.google.co.id/scholar?q=Pembelajaran+IPA+dan+Biologi+di+Indonesia+\(belum+memberdayakan+keterampilan+berpikir\)&hl=en&as_sdt=0&as_vis=1&oi=scholar](https://scholar.google.co.id/scholar?q=Pembelajaran+IPA+dan+Biologi+di+Indonesia+(belum+memberdayakan+keterampilan+berpikir)&hl=en&as_sdt=0&as_vis=1&oi=scholar)
- Supena, I., Darmuki, A., & Hariyadi, A. (2021). The influence of 4C (constructive, critical, creativity, collaborative) learning model on students' learning outcomes. *International Journal of Instruction*, 14(3), 873–892. <https://doi.org/10.29333/iji.2021.14351a>
- Susetyarini, E., & Fauzi, A. (2020). Trend of critical thinking skill researches in biology education journals across Indonesia: From research design to data analysis. *International Journal of Instruction*, 13(1), 535–550. <https://doi.org/10.29333/iji.2020.13135a>
- Tanu, T., Cao, Y., Weinhandl, R., & Tamur, M. (2022). A meta-analysis of the effects of E-books on students' mathematics achievement. *Heliyon*, 8(May), e09432. <https://doi.org/10.1016/j.heliyon.2022.e09432>
- Tivani, I., & Paidi. (2016). Pengembangan LKS biologi berbasis masalah untuk meningkatkan kemampuan pemecahan masalah dan karakter peduli lingkungan developing. *Jurnal Inovasi Pendidikan IPA*, 2(1), 35–45. <https://doi.org/10.21831/jipi.v2i1.8804>
- Uniati, O., Jumiarni, D., & Yani, A. P. (2019). Pengembangan lembar kerja peserta didik berdasarkan Keragaman jenis tanaman di green chemistry dan kebun biologi Universitas Bengkulu. *Diklabio: Jurnal Pendidikan Dan Pembelajaran Biologi*, 3(1), 17–24. <https://doi.org/10.33369/diklabio.3.1.17-24>
- Van Laar, E., van Deursen, A. J. A. M., van Dijk, J. A. G. M., & de Haan, J. (2020). Determinants of 21st-century skills and 21st-century digital skills for Workers: A systematic literature review. *SAGE Open*, 10(1). <https://doi.org/10.1177/2158244019900176>
- Wahyuni, S., Halim, A., Evendi, E., Syukri, M., & Herliana, F. (2021). Development of student worksheets based on investigative science learning environment (ISLE) approach to improve students' creative thinking skills. *Jurnal Penelitian Pendidikan IPA*, 7(Special Issue), 39–45. <https://doi.org/10.29303/jppipa.v7ispecialissue.903>

- Wijaya, E. Y., Sudjimat, D. A., & Nyoto, A. (2016). Transformasi pendidikan abad 21 sebagai tuntutan pengembangan sumber daya manusia di era global. *Jurnal Pendidikan*, 1, 263–278. <https://core.ac.uk/download/pdf/297841821.pdf>
- Yaumi, M. (2018). *Media dan teknologi pembelajaran* (S. F. S. S. Sirate (ed.)). Prenada Media. <https://core.ac.uk/download/pdf/227425718.pdf>
- Yuliani, H., Mariati, Yulianti, R., & Herianto, C. (2017). Keterampilan berpikir kreatif pada siswa sekolah menengah di Palangka Raya menggunakan pendekatan saintifik. *Jurnal Pendidikan Fisika Dan Keilmuan (JPFK)*, 3(1), 48–56. <https://doi.org/10.25273/jpfk.v3i1.1134>
- Yunus, H., & Alam, H. V. (2015). *Perencanaan pembelajaran berbasis kurikulum 2013*. Deepublish. https://scholar.google.co.id/scholar?hl=en&as_sdt=0%2C5&as_vis=1&q=H+Yunus%2C+HV+Alam+-+2015+Perencanaan+pembelajaran+berbasis+kurikulum+2013&btnG=
- Zhang, J., Zhu, F., Liu, N., & Cai, Z. (2022). Be in your element: The joint effect of human resource management strength and proactive personality on employee creativity. *Frontiers in Psychology*, 13(March). <https://doi.org/10.3389/fpsyg.2022.851539>
- Zulfiani, Suwarna, I. P., & Sumantri, M. F. (2020). Science adaptive assessment tool: Kolb's learning style profile and Student's higher order thinking skill level. *Jurnal Pendidikan IPA Indonesia*, 9(2), 194–207. <https://doi.org/10.15294/jpii.v9i2.23840>
- Zulfiani, Z., Yunistika, R., & Juanengsih, N. (2018). Enhancing students higher-order thinking skills through guided and free inquiry-based learning. *Atlantis Press: Advances in Social Science, Education and Humanities Research*, 115(ICEMS 2017), 28–31. <https://doi.org/10.2991/icems-17.2018.6>