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Development of Electronic LKPD Problem Based Learning in Differentiated Learning of Ecosystem Material to Improve Critical Thinking and Collaboration Skills of High School Students Phase E

Achmad Fanji Alhusein[1*], Anggi Tias Pratama[2]

[1] Magister Pendidikan Biologi, Fakultas Matematikan dan Ilmu Pengetahuan Alam, Universitas Negeri Yogyakarta, Yogyakarta, Indonesia.
[2] Pendidikan Biologi, Fakultas Matematikan dan Ilmu Pengetahuan Alam, Universitas Negeri Yogyakarta, Yogyakarta, Indonesia.

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Corresponding Author:
Achmad Fanji Alhusein
achmadfanjialhusein@gmail.com

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Abstract: This study aims to produce teaching materials in the form of electronic LKPD problem based learning on differentiated learning that is feasible, practical, and effective to improve critical thinking skills and student collaboration. This type of research is research and development with the ADDIE procedure. The research was conducted at SMA N 1 Jebus on class X students. Feasibility, practicality, and effectiveness tests were conducted to obtain research data. The field trial design used a quasi-experiment with a control group pretest-posttest design. The instrument feasibility test was assessed by material experts and media experts. Practicality was assessed by biology teachers and students. Product effectiveness was analyzed using descriptive and inferential statistics using the SPSS 29 MANOVA test and using n-gain score analysis. The results of this study are as follows: (1) The electronic LKPD problem based learning differentiated learning produced was declared to meet the feasibility based on the values obtained from the media expert validator of 90% (feasible) and the material expert validator of 100% (very feasible) to improve critical thinking skills and student collaboration in high school; (2) The electronic LKPD for problem based learning of differentiated learning produced meets practicality based on the biology teacher questionnaire in the limited trial, obtaining a score of 94.2% (very feasible) and the student response questionnaire was 90% (very feasible); (3) The electronic LKPD for problem based learning in differentiated learning of ecosystem material is effective in improving critical thinking and collaboration skills of class X SMA students based on the results of the MANOVA test.

Keywords: Collaboration; Critical thinking; Differentiated learning; Electronic LKPD; Problem based learning

Introduction

21st century learning is developed including critical thinking and collaboration skills (Masrinah et al., 2019). This century demands that the government produce skilled human resources (HR) who are able to compete globally, where the quality of these human resources depends on the quality of their education (Angga et al., 2022). Educational institutions must be able to facilitate students in critical thinking and collaboration. Collaboration skills are learning activities in groups aimed at exchanging thoughts/ideas, expressing ideas,

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attitudes, channeling opinions and skills that are owned and working together to achieve results or common goals in the desired group (Nurwahidah et al., 2021). The context of environmental learning in SMA N 1 Jebus due to mining, this collaboration ability is very important. In addition to collaboration, critical thinking skills of this century are also important in the era of globalization and rapid technology.

Critical thinking skills are the ability to think rationally in making decisions. Critical thinking is also able to analyze ideas or concepts after understanding the idea or concept (Duron et al., 2006; Karanja, 2021; Zhou et al., 2013; Brell, 1990; Celia et al., 2001; Yapicioglu et al., 2012; Shahin & Tork, 2013). Critical thinking skills are in demand in today's global era because basic skills are needed to solve complex problems, analyze information, and make the right decisions. This is important to build a strong understanding of issues such as ecosystems, especially in the context of environmental challenges due to tin mining. This is relevant when studying complex environmental issues, such as the impact of tin mining on the ecosystem around SMA N 1 Jebus.

In reality, biology learning has various difficulties for students in gaining knowledge. Difficulties can be seen from the low biology learning outcomes based on preliminary tests and teacher interview results. Researchers obtained students' critical thinking skills and obtained from the five indicators measured an average of 57.93. The results of the assessment of students' critical thinking skills seen from the five aspects observed only reached an average of 45% with a low category (Hidayati & Sinaga, 2019). Low learning outcomes can be caused by a lack of teaching materials, difficulty of the material level, and learning that does not utilize the environment around the students.

Independent Learning focuses on freedom and creative thinking (Rahayu et al., 2022). The independent curriculum focuses on essential materials and the development of student competencies at each stage. Independent learning is part of a policy that is currently being implemented. The implementation of this curriculum provides "independence" for students to learn in understanding the material (Marisa, 2021). Its implementation must support skills in critical thinking and problem solving, creativity and innovation, as well as skills in communicating and collaborating with fellow students (Manalu et al., 2022; Dewi et al., 2025; Kospian et al., 2025). One form of independence in learning is differentiated learning.

Differentiated learning is a method used by educators that is oriented towards the needs of students based on initial diagnostics (Herwina, 2021). The needs that educators can understand about students are learning styles. (Chetty et al., 2019) argues that there are three learning styles of students, namely visual, kinesthetic, and auditory. Based on the data from the learning style questionnaire that was conducted, it was obtained that students with a kinesthetic learning style were 48%, visual 32%, and auditory 20%. Students who have an auditory learning style tend to listen to something, kinesthetic learn through movement and touch, and in the visual learning style students tend to see something (Barokah et al., 2020). The implementation of differentiated learning must be supported by the selection of an effective learning model.

The Problem Based Learning (PBL) model has the characteristic of having problems that will give rise to critical thinking in students, then solving the problem, until finally gaining knowledge from the problem (Siddiq et al., 2020; Fitri et al., 2024; Malik et al., 2024). The characteristics of PBL also train students to think interdisciplinary, which even though it focuses on problems, solving the problems requires various relevant sources (Shofiya, 2020).

In fact, based on field observations, some weaknesses of LKPD (Student Worksheets) include: still in the form of question sheets, not implementing a scientific approach, and questions in LKPD only require answers without a meaningful investigation process. Ecosystem material is important material to learn, because this material is relevant to the environment. Ecosystem material has essential material that is integrated between disciplines which involve chemistry, physics, and geography which helps participants think. Tin mining, especially in the Bangka region, has a significant impact on the environment, such as ecosystem damage, water pollution, and loss of habitat for living things. Ecosystem material is very relevant to be studied in this area so that students understand how human activities such as mining affect the balance of nature. The school where the research was conducted, SMA N 1 Jebus, is located in an area close to tin mining activities.

Generally, the development of electronic LKPD is limited to LKPD with a certain learning model. The development of electronic LKPD that accommodates the characteristics of students is still very rare. The existence of electronic LKPD based on problem based learning in differentiated learning that is oriented towards scientific activities is also expected to help students in developing critical thinking and collaboration skills. Based on the background above, the researcher took the initiative to conduct a study entitled "Development of Electronic LKPD Problem Based Learning in Differentiated Learning of Ecosystem Material to Improve Critical Thinking and Collaboration Skills of High School Students Phase E".

Method

This research uses the ADDIE development model. According to Sugiyono (2013), The Research and Development (R&D) method is a type of research used to develop a teaching material product by first testing the product to be developed, looking for weaknesses and deficiencies in the product, then developing the product that has been tested by fixing the weaknesses so that later a suitable product will be found. The selection of the ADDIE model as a research design contains learning activities that are deliberately designed and developed to create a learning process in students, with a training program that will have the ability to cover the knowledge, skills, and attitudes needed to carry out tasks (Hidayat & Nizar, 2021).

Table 1. Stages and Activities of ADDIE Development Research

Development stage	Activity
Analysis	Identifying needs includes: *Needs analysis* *Analysis of student characteristics* *Material analysis*
Design	Designing the concept of electronic LKPD that will be developed along with the research instruments that will be carried out, including: *Selection of the electronic LKPD design developed* *Designing activity plans with Problem Based Learning syntax* *Designing critical thinking and collaboration instruments*
Development	Developing products in the form of electronic LKPD along with instruments. This stage includes: *Validation of electronic LKPD in the form of material experts, media experts, and teachers* *Variable critical thinking and collaboration instruments* *Revision I* *Limited trial* *Revision II*
Implementation	Implementing the developed electronic LKPD into school learning. This stage includes field trials.
Evaluation	Final revision of the electronic LKPD based on data obtained during the implementation stage of the electronic LKPD.

Before being tested on a large group, the product that has been designed and developed must first be tested for its feasibility. Trials are needed to determine the feasibility of the product that has been designed and developed so that it is feasible and in accordance with the needs in helping the learning process. The trial design in research such as Expert Feasibility Test, Limited Trial, and Field Trial. The trial design is as follows.

Table 2. Field Trial Design

Group	Pretest	Treatment	Posttest
Control	Y1	Z	Y2
Experiment	Y1	X	Y2

Description:
X : learning using electronic LKPD
Z : Learning using LKPD used by educators
Y1: Dependent variables measured before learning
Y2: dependent variable measured after learning

The trial subjects in the electronic LKPD development research consisted of media experts, material experts, biology teachers, and students. The subjects selected consisted of limited trial subjects and field trials. The limited trial subjects consisted of 25 grade XI students who had studied ecosystem material. This trial was conducted to determine the readability and responses of students to the developed electronic LKPD. In addition, 1 teacher from grade X also gave an assessment of the developed electronic LKPD. The field trial subjects were conducted in high school in grade X1 as the control class and X2 as the experimental class which were randomly selected using random sampling techniques.

Data collection techniques in this study were tests and non-tests. Test techniques were used to improve students' critical thinking skills in the control and experimental classes. The test instrument used was in the form of an essay to test critical thinking skills. The test was conducted before (pretest) and after (posttest) the use of electronic LKPD in biology learning activities. The data collection instruments that will be used in this development research are interview guides, material expert validation sheets, media expert assessment sheets, high school biology teacher questionnaire assessment sheets, student readability questionnaire sheets, critical thinking skills test assessment sheets, collaboration skills assessment sheets.

The data obtained from the trial activities consisted of qualitative and quantitative data. Qualitative data in the form of suggestions from media expert lecturers, material experts, biology teachers, and high school students, while quantitative data in the form of scores to

determine the quality of electronic LKPD and test/non-test scores on critical thinking and collaboration skills. The research and development data analysis techniques used by researchers in developing electronic LKPD on ecosystem material are as follows: product development data analysis, product validity and feasibility analysis, instrument validity and reliability analysis, critical thinking skills test analysis, collaboration skills analysis. Analysis of the effectiveness of PBL electronic LKPD was also carried out as follows: descriptive analysis, inferential statistical analysis, multivariate prerequisite test, multivariate normality test, linearity test, variance-covariance matrix homogeneity test, correlation test, and MANOVA test.

Result and Discussion

The development product produced in this study is a student worksheet media or LKPD in electronic form. Electronic LKPD will be applied to the learning of high school students in phase E of ecosystem material to improve critical thinking skills and collaboration of ecological pyramids.

This research is an R&D research with ADDIE development model design. In general, the stages in this ADDIE model consist of 5 steps, namely, Analysis, Design, Development, Implements, and Evaluate.

Based on the results of the needs analysis stage from the interviews conducted, several pieces of information were obtained: the curriculum used is the Merdeka curriculum, the learning process still uses textbooks, the method used is the conventional method, and there is no LKPD for critical thinking and collaboration skills. Based on the results of the needs analysis and curriculum analysis in high schools, a renewal is needed in the learning process. Therefore, the researcher chose to develop Student Worksheets (LKPD) that can facilitate students to be active and motivated in the learning process so that they can train critical thinking skills and bring out the collaboration skills needed by students.

The design stage is the design stage of the electronic LKPD design based on problem based learning that will be developed. LKPD products are designed using Canva which is then applied to the liveworksheet. The LKPD design that is developed independently from the title of the material, the purpose of using the LKPD, basic theory, activity steps, videos, questions, and conclusions based on assessments during the learning process. The design of the electronic LKPD content consists of 3 meetings, where each meeting contains instructions for using the LKPD, learning activities based on problem based learning syntax and contains materials that have been studied. At this development stage, the product that has been developed is then validated by experts and practitioners.

The development stage is carried out on the development of electronic LKPD based on problem based learning on ecosystem material, where this development is in accordance with the initial plan at the design stage and conducting product validation with experts and practitioners so as to produce a valid, feasible and ready-to-implement product.

The implementation stage of electronic LKPD which is declared valid and feasible to be implemented, then the electronic LKPD will be shared via the liveworksheet link and then implemented in the learning process activities. The LKPD product trial uses a quasi-experimental method with a nonequivalent pretest-posttest control group design. The number of trial subjects is 64 students divided into experimental and control classes.

After the electronic LKPD is made through various stages, at the development stage it will then be used at the implementation stage, then an evaluation will be carried out on various product qualities by looking at the response of educators. The evaluation stage plays a very important role both for improving the LKPD that is developed, this evaluation will be carried out by media experts, material experts, biology teachers, and students using validation sheets and feasibility assessment sheets. While the evaluation at the implementation stage is an evaluation of the effectiveness of the electronic LKPD problem based learning in improving critical thinking skills which are measured using a test in the form of essay questions and knowing the collaboration skills of students which are measured using a questionnaire.

The results of this development research are in the form of the feasibility of electronic LKPD based on problem based learning which will be tested on a limited basis to determine the implementation of learning and student responses through the LKPD that will be developed. Furthermore, a broad trial to other classes. This stage aims to improve critical thinking skills and student collaboration skills. The assessment given by media experts on electronic LKPD based on problem based learning can be seen in the following table.

Table 3. Results of Validation of Electronic LKPD by Media Experts

Assessment aspects	Average score	Results of each aspect	Criteria
Cover illustration	3.7	91	Very feasible
Content and design	3.6	90	Very feasible
Average		90	Very feasible

Table 3 shows that the results of the LKPD value analysis obtained from media experts averaged 90% and were included in the category of very suitable for use.

The assessments given by material experts are in the following table.

Table 4. Results of Validation of Electronic LKPD by Material Experts

Assessment aspects	Average score	Results of each aspect	Criteria
Material quality	4	100	Very feasible
Language Quality	4	100	Very feasible
Supporting qualities of feasibility	4	100	Very feasible
Average		100	Very feasible

The results of the analysis of the electronic LKPD value based on problem based learning obtained from material experts averaged 100%. These data can be interpreted that the electronic LKPD product has met the criteria of being very feasible and can be used in learning activities.

The results of the percentage increase in the N-gain value of critical thinking skills can be seen in the following table.

Table 5. Results of N-Gain Analysis of Critical Thinking Skills

	Experimental Class	Control Class
Average percentage (%)	67.87	6.74
N-gain	0.62	0.49
Criteria	Medium	Medium

The average value of critical thinking skills from the experimental class and the control class was then measured for the percentage increase using the N-gain formula. Based on Table 5, it shows that the percentage increase from the experimental class was 67.87% and the N-gain value was 0.62 with moderate criteria. While the average percentage value of the control class was 60.74% and the N-gain value was 0.49 with moderate criteria. The results of the N-gain analysis of the increase in critical thinking skills can be seen in Figure 1.

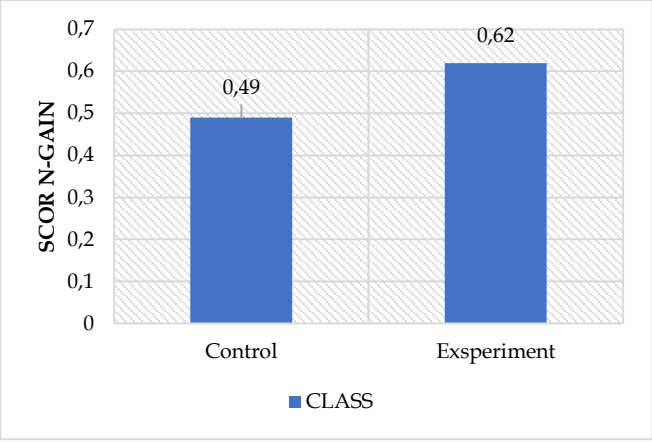


Figure 1. N-gain analysis of improving critical thinking skills

Figure 1 shows an increase in critical thinking skills in the control class and the experimental class. It can be concluded that the experimental class experienced a higher average increase in N-gain compared to the control class, so that learning activities using electronic LKPD based on problem based learning are effective in improving students' critical thinking skills.

The percentage value of the increase obtained from the average collaboration skills of the control class and the experimental class is measured using the N-gain formula. The N-gain value can be seen in the following table.

Table 6. Results of N-gain Analysis of Collaboration Skills Improvement

	Experimental Class	Control Class
Average percentage (%)	77.5	69
N-gain	0.47	0.17
Criteria	Medium	Low

Table 6 shows the average percentage value of the experimental class of 77.5% and the N-gain value obtained was 0.47 with moderate criteria. While the average percentage value of the control class was 69% and the N-gain value obtained was 0.17 with low criteria. It can be concluded that students' collaboration skills experienced significant differences between the control class and the experimental class.

Data analysis in this study used the MANOVA test. The data used were posttest data of critical thinking skills and collaboration skills. Before the MANOVA test was conducted, there were nine prerequisite tests that had to be met, namely: dependent variables measured at intervals and ratios and both were continuous data, independent variables consisted of two or more groups, observations were conducted independently and both groups were in different classes with different treatments, the sample used was 32 students consisting of control and experimental classes, there was no univariate or multivariate outliner, multivariate normality test, there was a linear relationship between each group of dependent variables and the group of independent variables, homogeneity test of the variance-covariance matrix, and finally the multicollinearity test. All prerequisite tests were met, so that it could be continued to the hypothesis test.

After conducting 9 prerequisite tests and concluding that all assumptions are met, the next step is to test the hypothesis using the MANOVA test with a significance level of 0.05% assisted by SPSS 29. Because the MANOVA test involves two dependent variables, the Decision criteria used are based on the Hotelling's Trace value. This study meets the requirements of data originating from a multivariate normally distributed population that has a homogeneous variance-covariance

matrix. The results of the MANOVA test analysis can be seen in Table 7.

Table 7. Multivariate MANOVA Test Results

Effect	Sig.	Partial Eta Square
Hotelling'Trace	0.000	0.798

Based on the results of the analysis, it can be concluded that the significance value of 0.00 <0.05 (p < 0.05), then H0 is rejected and Ha is accepted. If Ha is accepted, it can be stated that there is a difference in critical thinking skills and collaboration skills between students who take part in learning using electronic LKPD based on problem based learning and students who take part in learning without electronic LKPD based on problem based learning on ecosystem material carried out in high school.

The next stage of the MANOVA test is the test of between subjects. This test is used to determine the differences in LKPD against each research variable, namely critical thinking skills and students' collaboration skills. This hypothesis test is conducted to determine whether or not there is a significant difference in critical thinking skills between students who take part in learning using electronic LKPD based on problem-based learning and students who take part in learning without electronic LKPD based on problem-based learning on ecosystem material. This test is conducted using the Test of between Subjects by looking at the magnitude of the significance value and eta square. The following is Table 39 of the results of the critical thinking test.

Table 8. Results of the Test of Between Subjects Critical Thinking Ability

Variable	df	Mean Square	F	Sig.	Eta Square
Critical Thinking Skills	1	1225.000	45.081	0.000	0.421

Based on the results of the analysis, it can be concluded that the sig. value is 0.000 <0.05 (p < 0.05), so H0 is rejected and Ha is accepted. If Ha is accepted, it can be stated that there is a difference in critical thinking skills between students who take part in learning using electronic LKPD based on problem based learning and students who take part in learning without electronic LKPD based on problem based learning on ecosystem material.

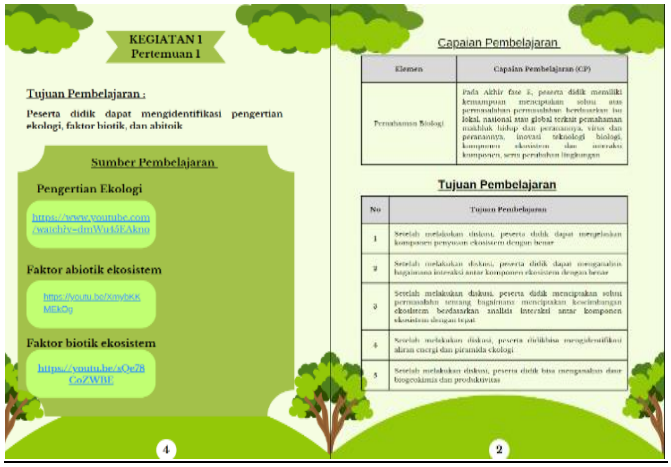
Next, the hypothesis test is to determine whether or not there is a significant difference in collaboration skills between students who take part in learning using electronic LKPD based on problem-based learning and students who take part in learning without electronic LKPD based on problem-based learning on ecosystem material. This test is carried out using the Between Subjects Test by looking at the magnitude of the significance value and eta square. The following is Table 9 of the results of the collaboration skills test.

Table 9. Results of the Test of Between Subject Collaboration Skills

Variable	df	Mean Square	F	Sig.	Eta Square
Collaboration Skills	1	2537.641	179.151	0.000	0.743

Based on the results of the analysis, it can be concluded that the sig value of 0.000 <0.05 (p <0.05), then H0 is rejected and Ha is accepted. If Ha is accepted, it can be stated that there is a difference in collaboration skills between students who take part in learning using electronic LKPD based on problem based learning and students who take part in learning without electronic LKPD based on problem based learning on ecosystem material.

Table 10. Comparison of Prototype I and Prototype II Results

Prototype I (before validation)	Prototype I (After Validation)
Cover View	
	
LKPD Content View	
	

Prototype I (before validation) Prototype I (After Validation)

The validation results and suggestions or input from the validator are used as a reference by the researcher in revising the LKPD in order to perfect the product being developed. The revised result of prototype I is Prototype II, then if it is declared valid it will be tested on a limited basis in class XI of high school. The results of the comparison between Prototype I and Prototype II which have been revised and adjusted to the suggestions and input from validator I and validator II experts can be seen in the table 10.

This research is a type of R&D development research conducted by referring to Branch's theory. The final result of this development research is to produce a teaching material product, namely an electronic Student Worksheet (LKPD) based on problem-based learning. The initial stage in developing an electronic LKPD based on problem-based learning is to conduct a preliminary study. Based on the results of the preliminary study, it states that the teaching materials used in schools are still in the form of school textbooks and LKPDs made by educators themselves and used by educators in learning activities, but students only listen to the information provided by educators then work on assignments in the form of sheets containing questions contained in the LKPD without being actively involved in the learning process.

The next stage is the validation stage of the electronic LKPD product. Validation is an assessment carried out by expert material validator lecturers, media experts, and practitioners. The assessment is carried out using a questionnaire consisting of 2 assessment aspects and totaling 10 questions. The aspects assessed are cover illustrations, content, and design. The results of the media expert assessment with an average score of both aspects obtained a value of 90% and were stated in the criteria of very feasible. It can be concluded that the product is feasible to use with revisions from suggestions and input by the validator. Validation of material experts on electronic LKPD products based on problem based learning was carried out by lecturers. The assessment was carried out using a questionnaire sheet consisting of three assessment aspects, namely the aspect of material quality, language quality, and quality of supporting feasibility and totaling 15 question items. The results of the assessment from the material expert obtained an average value of 100% and were stated in the criteria of very feasible to use in the learning process. Validation of the biology teacher's response was carried out by one of the biology educators of class X SMA. The aspects assessed were the aspect of material feasibility, material accuracy, didactic aspects, construction aspects, and technical aspects with 25 question items. The results of the educators' response scores obtained an average of 94.2% and were stated in the criteria of being feasible and can be used as biology teaching materials in schools.

Before conducting the research, first a trial of critical thinking essay questions was conducted in high school in grade XI with 25 students selected using random sampling techniques. Furthermore, from the results of the trial of the question instrument, a test was carried out to determine the validity and reliability of the questions. The results of the validity of the question items were obtained from the test results of 16 essay questions, 13 questions were declared valid and based on the results of the reliability calculation, the test questions had a reliability index of 0.906, it can be concluded that the test has criteria that are suitable for use in learning activities. This is supported by Sanaky (2021) in his research that the high or low reliability can be indicated by a number that can be called the reliability coefficient value. High reliability is reflected by the rxx value approaching 1. In general, reliability is considered quite satisfactory if ≥ 0.700, if alpha > 0.80 suggests that all items are reliable and all tests consistently have strong reliability.

In addition to the validity and reliability tests, an analysis calculation was carried out on the average increase in students' critical thinking ability tests which can be seen in Table 30. The average pretest value of critical thinking ability in the control class was 48.03 and the average posttest was 73.43. Meanwhile, the results in the experimental class obtained a pretest of 53.56 and an average posttest of 82.18. So it can be concluded that electronic LKPD based on problem based learning in the

experimental class is able to improve critical thinking skills in students. The percentage of N-gain increase in critical thinking ability calculated using the N-gain formula can be seen in Table 31 showing that the experimental class obtained a value of 0.62 and was stated as a moderate criterion. In the control class, it was 0.49 and was included in the moderate criteria. This is in line with Prasetyono et al. (2020) in his research, an increase in critical thinking skills can be done by analyzing the gain score with the highest criteria, namely (N-gain ≥ 0.7), medium criteria, namely (0.7 > N-gain ≥ 0.3), and low criteria, namely (<0.3).

Based on the results of the data analysis, the improvement of students' collaboration skills was carried out with 32 students in the experimental class and the control class by providing a questionnaire sheet at the beginning and end of the meeting. The results of the N-gain analysis can be seen in Table 33, there is an increase in students' collaboration skills. In the experimental class, the N-gain was obtained at 0.47 and was stated as moderate. In the control class, the N-gain was obtained at 0.17 and was stated as low criteria. Based on the average percentage of the collaboration skills aspects achieved by students in the experimental class, the value was 77.5% and was stated as good criteria, while the control class obtained an average percentage value of 69% and was stated as good criteria.

After all prerequisite tests are met, then a multivariate analysis of variance or MANOVA test is performed. MANOVA is a statistical method used to analyze data consisting of one or more types of variables, where the variables have a relationship between each other. MANOVA is a linear member of a set of statistical products that are often used to measure the strength between variables (Sutrisno & Wulandari, 2018). Therefore, the MANOVA test is used to measure the influence of independent variables on a number of dependent variables at once or simultaneously.

The results of data analysis and hypothesis testing obtained data on electronic LKPD based on problem based learning have an influence on critical thinking skills and collaboration skills. The results of the calculation of hypothesis test data using MANOVA show that the data obtained is significant 0.000 <0.05, then H0 is rejected and Ha is accepted, so it can be concluded that there is a significant difference in critical thinking skills and collaboration skills between students who learn using electronic LKPD based on problem based learning differentiated learning on ecosystem material (experimental class) with students who learn not using electronic LKPD based on problem based learning on ecosystem material (control class) conducted in high school.

Based on the achievement of critical thinking ability indicators obtained from the average value, it can be concluded that electronic LKPD based on problem based learning has increased students' critical thinking abilities, this is in line with previous research from Amalia et al. (2022) entitled the quality of electronic LKPD on the concept of plantae based on critical thinking skills at the high school level, revealed that electronic LKPD is classified as effective with an average value of 97.32 and effectiveness is classified as very high based on six critical thinking indicators including interpretation 96.43%, analysis 91.9%, evaluation 92.2%, inference 94.54%, explanation 92.2%, and self-regulation 95%. So it can prove that the use of electronic LKPD for learning, especially with the help of a problem-based learning model, can improve students' critical thinking skills.

Based on research conducted by Rahmawati et al. (2022) entitled development of electronic LKPD based on live worksheet concept of circulatory system to improve critical thinking skills of high school, that the use of LKPD live worksheet in the learning process can improve critical thinking skills of students with the obtained data of practicality results with a percentage of 98% and the effectiveness of using electronic LKPD live worksheet with categories of six critical thinking indicators, obtained five with very good criteria, namely aspects of interpretation, analysis, evaluation, explanation, and self-regulation. While in the inference obtained a good category. So, it can be concluded that biology learning using electronic LKPD live worksheet has an effect on students' thinking skills at school.

Fulfillment of students' learning needs is one of the criteria for implementing differentiated learning. Fulfillment of needs can be done by providing diverse learning content so that it can be a choice for students to choose their learning needs according to the wishes of students (Andajani, 2022). Educators give students the freedom to choose content that suits them. Based on the learning that is done, differentiated learning can improve student achievement and their learning needs are met because they are in accordance with their wishes. The application of differentiated learning requires educators to have a variety of content that suits students. The application of differentiation can be given videos, images, materials, discussions in groups. Because, the educator is a facilitator in the learning process (Himmah et al., 2023; Mardani et al., 2024; Gusteti et al., 2022; Astuti et al., 2022; Naibaho, 2023).

Based on the trial conducted, the output of the paired sample t test of student learning outcomes with a sig value of 0.000 <0.05 was obtained, so H0 was rejected and Ha was accepted, it was concluded that electronic LKPD had a significant influence in improving student learning outcomes. So it can be concluded that electronic LKPD has a significant influence because it presents material containing interesting images and videos so

that it can support student understanding. Integration of teaching materials with learning models stimulates the learning process by students. Through electronic LKPD provided with problem-based learning, students are given the opportunity to find and solve problems given with the support of their surroundings. Students who have critical thinking skills do not just have basic skills for critical thinking, but have the ability to apply them in evaluations.

Nugraha et al. (2017) revealed that motivation is related to critical thinking, meaning that when students have high learning motivation, it will be reflected in their learning outcomes. When learning motivation is high, critical thinking skills will be seen from the intensity of learning and effort in the process. Electronic LKPD learning based on problem based learning is very good for improving critical thinking skills of high school students in ecosystem material. This is supported by the opinion of Sarifah et al. (2023) states that critical thinking skills are not only skills that can be acquired individually, but can be developed collaboratively or in cooperation. The importance of learning in groups collaboratively to achieve certain learning objectives in addition to being able to improve critical thinking skills is also able to improve student collaboration.

The electronic student worksheet based on problem based learning that was developed has characteristics that are appropriate in terms of content, construction, and language. According to Kaharuddin et al (2021) the characteristics of electronic LKPD that have been adjusted to the PBL learning model. Electronic LKPD based on problem based learning has practical criteria based on practicality tests. Practicality criteria with characteristics, namely electronic LKPD is easy to use, has clear instructions for use, and how the activities are aimed at each meeting. The learning process makes it easier for students to use LKPD products. In addition, LKPD also meets the criteria for eligibility, this is explained that LKPD is feasible if the percentage of eligibility reaches 51-75%. Electronic LKPD based on problem based learning is also effective for use in learning biology on ecosystem material through effectiveness tests. As research conducted by Rochman et al. (2021) stated that electronic LKPD based on problem based learning can help students' learning activities, so that the electronic LKPD products produced in this study have met the characteristics of being practical, feasible, and effective. With the use of this LKPD in learning, students can improve their understanding in solving a problem presented.

Conclusion

Electronic LKPD problem based learning in differentiated learning is very suitable for use in biology learning on ecosystem material phase E. Electronic LKPD is part of the development of digital skills that will indirectly train digital literacy in learning platforms and have digital security. In addition to having easy and interesting access. Electronic LKPD problem based learning in differentiated learning is practically used for biology learning on ecosystem material phase E reviewed from the assessment of expert practitioners, namely teachers and students. This is more practical in terms of time management in completing tasks, interactive, flexible, and accessibility for students during learning. Electronic LKPD problem based learning in differentiated learning is effective in improving critical thinking skills and student collaboration which can be reviewed from the test results showing that LKPD problem based learning in differentiated learning can improve critical thinking skills and student collaboration in the experimental class of class X. This is because of the integration of technology in student teaching materials with the PBL learning model, then there is differentiated learning that supports and meets student learning needs, so that the combination of all these factors makes students actively participate during dynamic and integrated learning.

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There is no conflict of interest.

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