

Development of E-LKPD Based on RADEC Learning Model (Read, Answer, Discuss, Explain, Create) Integrated with Socio- Scientific Issues to Train Students' Scientific Argumentation Skills

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DOI: <http://dx.doi.org/10.18592/tarbiyah.v14i2.17972>

Keywords :

E-LKPD
scientific
argumentation skills
RADEC
Socio-Scientific Issue

Accepted : 07 August 2025
Revised : 30 December 2025
Accepted : 31 December 2025
Published : 18 January 2026

Abstract:

This study aims to analyze the validity of the developed E-LKPD. The method used is (R&D) with a 4D development model. The sample in this study were 34 students of class X of SMA Negeri 12 Semarang and the sampling technique used was *purposive sampling*. The data collection instrument was a validation questionnaire assessed by expert validators of media, materials, learning methodology, scientific argumentation, teacher and student assessments. The percentage of validation results from media experts was 87.5%, material experts were 97.2%, learning methodology experts were 87.5%, scientific argumentation skills experts were 90.6%, and biology teacher assessments were 98%. The student readability test showed a percentage of 88%. Based on the results of the overall data analysis, it was concluded that the E-LKPD based on the RADEC model integrated with SSI to train scientific argumentation skills was declared valid and good for use in Biology learning.

Citing this article: Barokah. W.L., Akmalia. H.A., Ruswan. R. (2025). Development of E-LKPD Based on RADEC Learning Model (*Read, Answer, Discuss, Explain, Create*) Integrated with *Socio-Scientific Issue* to Train Scientific Argumentation Skills of Grade X Students. *Tarbiyah: Jurnal Ilmiah Kependidikan*. 14(2), 457-472.

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Introduction

Education in the 21st century needs to emphasize the development of *4C Skills*, which include critical thinking, communication, creativity, and collaboration (Mardhiyah et al., 2021). In addition to these four skills, UNESCO also established four pillars of 21st-century education: *learning to know, learning to be, learning to do, and learning to live together* (Zubaidah, 2016). Argumentation skills are included as one element of *learning to know*, namely the skills individuals possess to express an opinion based on facts that support that opinion (Anila et al., 2015).

Scientific argumentation skills are one of the main objectives in science learning. Students studying science must understand scientific explanations of natural phenomena and use arguments to solve problems so they can understand other findings. Students who have a comprehensive understanding of science must be able to understand the language of science and actively engage in scientific activities such as argumentation and observation (Probosari et al., 2016). Furthermore, scientific argumentation skills can enable students to understand the arguments of a proposed theory. Students will generate new ideas in the field of education, especially science, deepening their understanding and thinking about the material being studied (Anita et al., 2019).

Based on the results of pre-research through interviews and testing of scientific argumentation skills of class X students at SMAN 12 Semarang on December 16th 2024, also with one of the biology teachers of class X, it was found that the students' scientific argumentation skills during learning are relatively low. This happens because they do not yet know about scientific arguments according to existing indicators and are still afraid to put forward their arguments if the arguments they put forward are wrong. This is similar to the results of interviews with representatives of students from class X who stated that they are still hesitant to put forward their arguments because they are afraid that the arguments they put forward are wrong. Based on the questionnaire of student needs analysis in class X with a total of 33 students, the results showed that 58.8% of students did not have a deep understanding of scientific argumentation. This was also proven by the trial of scientific argumentation questions using four indicators from McNeill & Krajcik (2011). The result showed that the percentage of students' scientific argumentation skills was 46% divided into claim indicators (53%), evidence (50.5%), reasons (40.3%), and rebuttal (40.3%). The level of students' scientific argumentation in these four indicators is relatively low. The low scientific argumentation skills can be seen from the results of students' answers in answering questions related to scientific argumentation given by researchers. They can answer questions but without providing strong reasons and evidence, even they only provide claims, while from the scientific argumentation indicators in the form of evidence, reasons, and rebuttals are not answered correctly.

The factors that cause low scientific argumentation above are also supported by research from Rahayu et al. (2020), proving that low scientific argumentation skills come from students' inadequate understanding of the ideas and concepts of the material being studied. Another factor is that students rarely receive training in argumentation because during the learning process they have not been facilitated to argue well both orally and in writing, therefore students are not used to doing argumentation tests. According to Pritasari et al. (2016), if students are not used to practicing arguing, they will have difficulty formulating questions and constructing answers, even though argumentation skills are an important aspect of the learning process to develop quality arguments.

Scientific argumentation skills can be trained through the RADEC learning model. The RADEC (*Read, Answer, Discuss, Explain, Create*) learning model is an alternative learning model that is suitable for educational conditions in Indonesia. This learning model is considered ideal because it can accommodate various key issues in learning. This model aims to prepare students with the knowledge, attitudes, and skills competencies needed in the 21st century. The syntax of this learning model is easy to understand and memorize by teachers from elementary to secondary levels, making it suitable for use as a creative and innovative learning model in Indonesia (Sopandi, 2021). The RADEC learning model needs to be integrated with a learning approach to train students' scientific argumentation skills specifically because the RADEC learning model emphasizes scientific literacy (Sopandi, 2017). One learning approach that can be integrated with the RADEC model is *the Socio-Scientific Issue*. This learning approach connects material with social issues in society that can support the development of intellectual skills, social attitudes, communication, awareness, and student participation (Zeidler et al., 2005). *The Socio-Scientific Issue (SSI)* learning approach is a learning approach that refers to social scientific problems that arise due to technological developments and research that have a direct impact on society (Sadler & Zeidler, 2004).

The RADEC learning model and the *Socio-Scientific Issue learning approach* can be integrated to train scientific argumentation skills, packaged in teaching materials such as modules, worksheets (LKPD), articles, videos, and others. Based on the researcher's needs analysis, electronic LKPD teaching materials are the preferred teaching materials for students to practice their scientific argumentation skills. This aligns with research by Umbaryati (2022), which states that LKPD is used as a guideline for educators and students using the RADEC model because each stage can be designed with instructions and task formats according to the stages in this model. In this E-LKPD, the RADEC syntax integrated with SSI is included in the activity stages created by adjusting the scientific argumentation indicators. The use of E-LKPD can essentially help students in solving problems, so the teacher's role as a facilitator is important in creating a pleasant learning atmosphere. E-LKPD is flexible, easily accessible anytime and anywhere, making it a means of entertainment as well as a learning aid (Rahayu., 2022).

The purpose of this study is to develop an E-LKPD based on the RADEC model integrated with *Socio-Scientific Issues* that is valid for use in biology learning for grade 10, specifically on ecosystems, environmental change, and biological technology innovation. This study also aims to analyze student responses to the use of the developed product.

Research Method

This research is a type of research and development (R&D). The research design uses the 4D development model: *define, design, develop, and disseminate* (Thiagarajan & Sivasailam, 1974). This research is limited to the *development stage* only. The 4D model was chosen in this study because each step in the 4D development procedure explains in detail what the researcher will do in developing the E-LKPD product.

The research was conducted at SMA Negeri 12 Semarang. The sample in this study were 34 students of grade X and the sampling technique used was *purposive sampling*. This technique was chosen to determine a sample that represents various academic abilities of students to obtain a comprehensive picture of student readability. Data collection techniques in this study were based on the results of interviews, questionnaires, and tests. Data analysis used for the development of E-LKPD used qualitative and quantitative data analysis techniques. Qualitative data analysis includes 4 main stages: data collection, data reduction, data presentation, and conclusions. Quantitative data analysis includes validation tests from experts, biology teacher assessments, and readability tests from students.

The validation questionnaire from experts, biology teacher assessment, and student readability test used a four-point scale shown in Table 1. The scoring system followed the scoring scale and percentage scores obtained from the research and was described based on the criteria outlined in Table 2 below.

Table 1. Assessment Scores

Score	Information
4	Very Good (SB)
3	Good (B)
2	Not Good (TB)
1	Very Bad (STB)

(Sugiyono, 2022)

Table 2. Percentage Criteria

No.	Percentage	Criteria
1.	85.01% - 100.00%	Very Valid
2.	70.01%-85.00%	Quite Valid
3.	50.01%-70.00%	Less Valid
4.	01.00-50.00%	Invalid

(Akbar, 2017)

Results and Discussion

The teaching material in the form of E-LKPD based on the RADEC (*Read, Answer, Discuss, Explain, Create*) learning model integrated with *Socio-Scientific Issue* contains stages of learning activities to train students' scientific argumentation skills. Each learning activity is designed to actively involve students in providing arguments based on scientific argumentation indicators from McNeill & Krajcik (2011), comprising *claim, evidence, reasoning, and rebuttal*. The developed E-LKPD was validated by 4 expert lecturers, who experts in media, materials, learning methodology, and scientific argumentation skills. After being validated by experts, a field test was conducted, namely through assessments by biology teachers and readability tests of student grade X.

Initial Product Development Results

The product development results in the form of an E-LKPD on ecosystems, environmental change, and biotechnology innovation aim to train students' scientific argumentation skills. This product development model uses the 4D model: *define, design, and is limited to the develop stage*.

1. Define

The definition steps consist of five stages which are carried out as follows:

a. Front end Analysis

Front-end analysis was used to identify deficiencies in the use of teaching materials in the learning process. Researchers interviewed biology teachers at SMA Negeri 12 Semarang to identify problems encountered during the learning process, including the teaching materials used, biology learning resources, learning media, learning models, and teaching methods used by teachers during the learning process. The analysis results were used to refine the teaching materials that the researchers will develop. Researchers also administered a scientific argumentation test through a provided *Google form*.

Pre-research was conducted in December 2024 through interviews with biology teachers at SMA Negeri 12 Semarang who stated that during the learning process they had never used teaching materials in the form of E-LKPD using the RADEC (*Read, Answer, Discuss, Explain, Create*) learning model integrated with *Socio-Scientific Issues* , so the researcher developed the product as a supporting teaching material in the learning process.

b. Learner Analysis

Learner Analysis is a crucial step in the initial design phase. A student needs analysis questionnaire is used to identify the biology teaching materials students will use in their learning. The results of the student needs analysis questionnaire showed that 91.2% of students preferred electronic or online teaching materials, and 76.5% agreed that e-LKPD teaching materials would be developed.

c. Task Analysis

Task analysis aims to identify student skills (Waruwu, 2024). Task analysis is tailored to the desired learning objectives.

d. Concept Analysis

Concept analysis is in accordance with learning objectives, namely ecosystem material, environmental changes, and innovation in class X biology technology.

e. Specifying Instructional Objectives (Formulating Learning Objectives)

The learning objectives formulated in this E-LKPD cover three topics: ecosystems, environmental change, and biological technology innovation. These learning objectives are aligned with existing learning outcomes. The purpose of this E-LKPD is to enable students to practice effective scientific argumentation.

2. Design

Design Stage has 4 stages, namely:

a. Criterion-Test Construction

The instrument for assessing product feasibility was adapted from the reference test. The questionnaire used was equipped with a Likert scale to assess the validity of the E-LKPD product.

b. Media Selection

The media selection in this E-LKPD product is supported by material from valid sources and additional references in the form of *YouTube videos*. The RADEC (*Read, Answer, Discuss, Explain, Create*)-based E-LKPD integrated with *Socio-Scientific Issues* was created using the Canva application for cover design, background, and material content. The stages of learning activities use the *Topworksheets website* which will later be in the form of a link used to work on assignments in the E-LKPD, then the E-LKPD will be packaged in the form of flip and links using the *Heyzine website*.

c. Format Selection

RADEC (*Read, Answer, Discuss, Explain, Create*) integrated *Socio-Scientific Issue-based E-LKPD* is designed attractively and can be easily accessed online using a cellphone or computer in the form of a link.

d. Initial Design (Design Draft)

The following is the initial design draft of the E-LKPD product being developed:

- 1) Compile a list of references and books on ecosystem materials, environmental change, and biotechnology innovation.
- 2) Analyzing the independent curriculum based on Learning Outcomes and Learning Objectives.
- 3) Develop a concept of the material to be studied based on learning objectives.
- 4) Designing the E-LKPD product design includes selecting the cover, *background*, supporting images, borders, title elements, and E-LKPD content which are linked to the RADEC (*Read, Answer, Discuss, Explain, Create*) stages integrated with *Socio-Scientific Issues* which are linked to scientific argumentation skills.
- 5) Creating expert validation instruments includes media experts, materials, learning methodology, and scientific argumentation skills.

3. Develop

The aim of the Develop stage is to create electronic teaching materials in the form of E-LKPD which includes expert validation and development trials from biology teacher assessments and readability tests for class X high school students.

Expert Validation

The e-LKPD product was validated by expert validators, including lecturers specializing in media, lecturers specializing in material, lecturers specializing in learning methods, and lecturers specializing in scientific argumentation skills. Next, the product was assessed by biology teachers as practitioners, and student responses to the developed e-LKPD were tested. The stages and results of the e-LKPD product trial are presented as follows:

Media Expert Validation Results

The E-LKPD product was validated by media expert lecturers, covering aspects of E-LKPD presentation, graphic feasibility, E-LKPD display quality, software engineering aspects, images, illustrations, and videos. The media validation results are presented in Table 3 below.

Table 3. Media Expert Validation Results

No	Aspect	Percentage	Criteria
1.	Presentation of E-LKPD	87.5%	Very Valid
2.	Graphical feasibility	80%	Quite Valid
3.	Images, illustrations and videos	100%	Very Valid
4.	E-LKPD display quality	100%	Very Valid
5.	Software engineering aspects	100%	Very Valid
Overall Percentage		87.5%	Very valid

Based on the validation of media experts, the percentage of results obtained in the presentation aspect was 87.5%, the graphic feasibility aspect was 80%, images, illustrations, and videos were 100%, display quality was 100%, and the software engineering aspect was 100%. This high validity percentage indicates that the developed E-LKPD has an appeal and the media used is easy to access and is very valid for use in learning. Revisions from media experts include images and the abbreviation RADEC on the cover, concept maps, and apperception. The following is an image of the revised section from the media expert validator.



Figure 1. Cover Section Before Revision



Figure 2. Cover Section After Revision

Development of E-LKPD Based on the RADEC Learning Model...

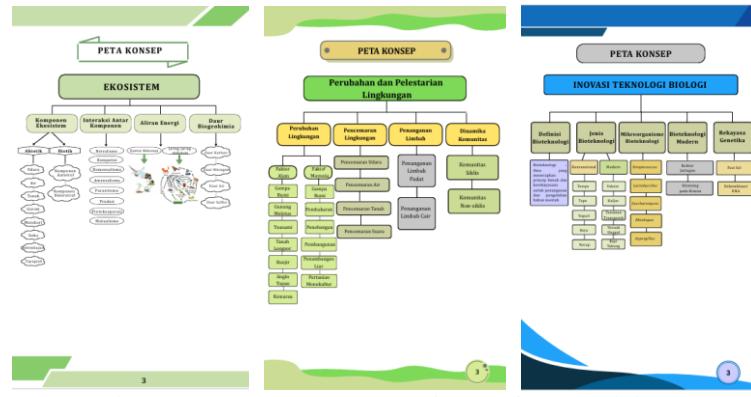


Figure 3. Concept Map Section Before Revision

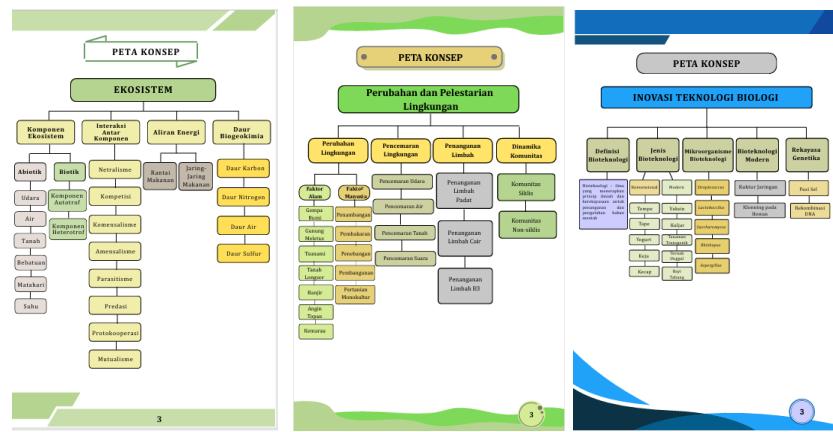


Figure 4. Concept Map Section After Revision

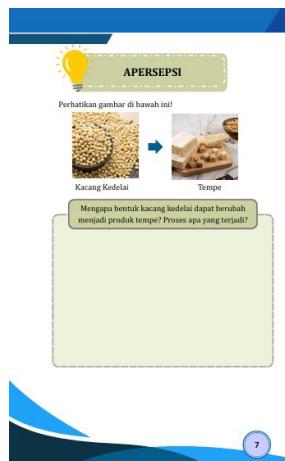


Figure 5. Apperception Before Revision

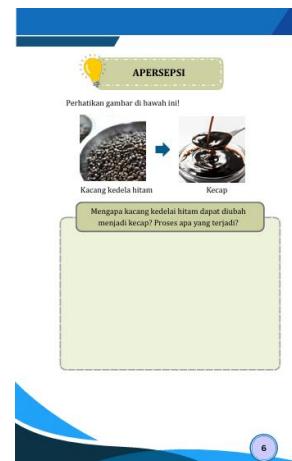


Figure 6. Apperception After Revision

Subject Matter Expert Validation

The E-LKPD product was validated by expert lecturers covering aspects of content suitability, presentation, and language. The validation results from the expert lecturers on the E-LKPD are presented in Table 4 below.

Table 4. Results of Material Expert Validation

No	Aspect	Percentage	Criteria
1.	Suitability of material content	95.8%	Very Valid
2.	Presentation suitability	96.8%	Very Valid
3.	Language eligibility	100%	Very Valid
Overall percentage		97.2%	Very Valid

Based on the validation of material experts, the percentage of results obtained was The feasibility aspect of the material content was 95.8%, the feasibility of presentation was 96.8%, and the feasibility of language was 100%. The overall percentage was 97.2%, which had very valid criteria, so the material contained in the E-LKPD was very valid for use. The material contained in this E-LKPD was ecosystems, environmental change, and biological technology innovation. The importance of validating the material to be included in this E-LKPD was to determine whether the material used was in accordance with the learning objectives (Mista et.al., 2024). In addition, the validity of the material in a teaching material was very important because it ensured that the content was appropriate, in accordance with the curriculum used, and scientifically accurate. Revisions from material experts included the image section on the energy flow material and the writing of the bibliography. The following is an image of the revision section from the material expert validator.



13



38



Figure 8. After Revision



42

Learning Methodology Expert Validation Results

The E-LKPD product was validated by biology learning methodology experts in the form of an integrated RADEC learning model with *Socio-Scientific Issues* that includes the stages of the RADEC model, SSI criteria and objectives. The validation results from the learning methodology experts in E-LKPD are presented in Table 5 below.

Table 5. Results of Learning Methodology Validation

No.	Aspect	Percentage	Criteria
1.	RADEC model syntax	90%	Very Valid
2.	RADEC's objectives	75%	Quite Valid
3.	SSI Criteria	87.5%	Very Valid
4.	SSI Objectives	100%	Very Valid
Overall percentage		87.5%	Very Valid

Based on the validation results from the learning methodology expert on E-LKPD which consists of 4 aspects, namely the RADEC model syntax aspect, the percentage of the RADEC model syntax was 90%, the RADEC objectives 75%, the SSI criteria 87.5%, and the SSI objectives 100%. The overall percentage of 87.5% which has very valid criteria, so the learning methodology contained in E-LKPD is very valid to use. Revisions from the learning methodology expert include the Learning Outcomes (CP) section, the SSI integrated RADEC syntax and learning reflection. The following is a picture of the revised section from the learning methodology expert validator.

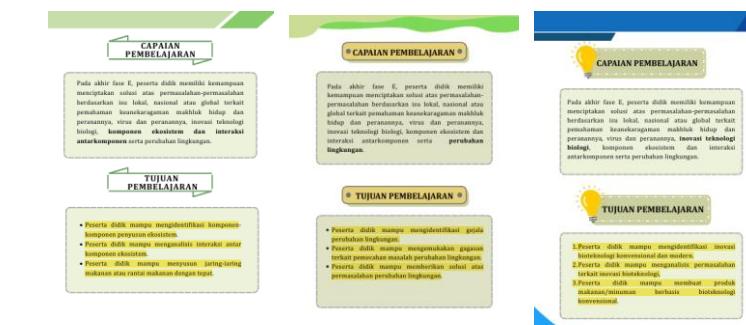


Figure 11. Learning Objectives Before Revision



Figure 12. Learning Objectives After Revision

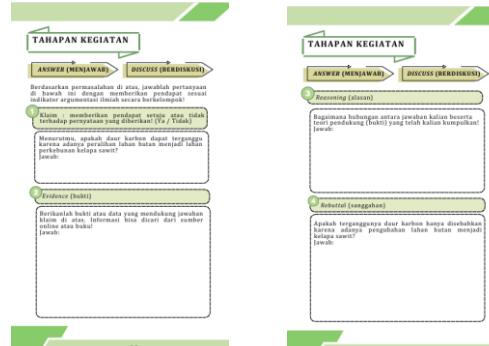


Figure 13. Learning Stages Before Revision

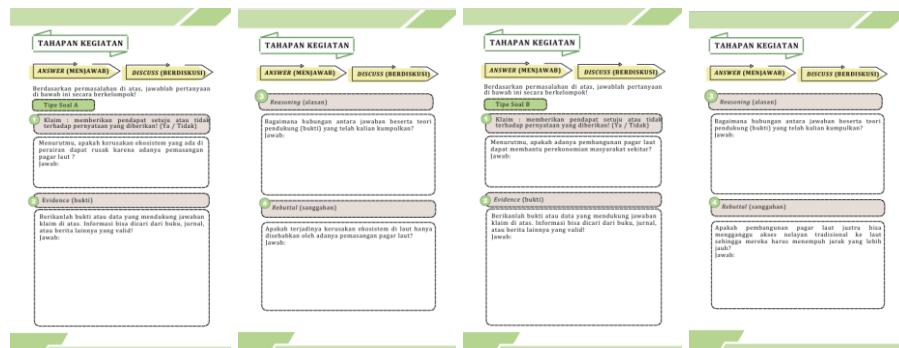


Figure 14. Learning Stages After Revision

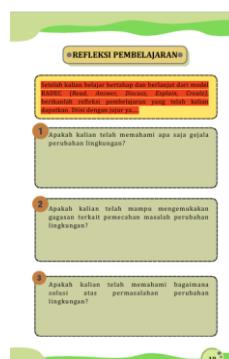


Figure 15. Before Revision



Figure 16. After Revision

Expert Validation Results of Scientific Argumentation Skills

The E-LKPD product was validated by a scientific argumentation skills expert using the criteria [McNeill & Krajcik \(2011\)](#). The validation results from the scientific argumentation skills expert in E-LKPD are presented in Table 6 below.

Table 6. Results of Validation of Scientific Argumentation Skills

No.	Aspect	Percentage	Criteria
1.	Fill in the E-LKPD according to the scientific argumentation indicators	93.7%	Very Valid
2.	Linguistics	87.5%	Very Valid
Overall percentage		90.6%	Very Valid

Based on the validation results from the scientific argumentation skills expert on E-LKPD, the percentage of 2 aspects was obtained, namely the content of E-LKPD according to the scientific argumentation indicator with a percentage of 93.7% and language at 87.5%. The overall percentage of 90.6% has very valid criteria, so that the questions contained in the scientific argumentation skills in E-LKPD are very valid to use. The revision from the scientific argumentation skills expert is in the *reasoning section*. The following is an image of the revised section from the scientific argumentation skills expert validator.

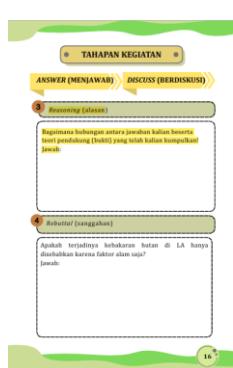


Figure 17. Before Revision

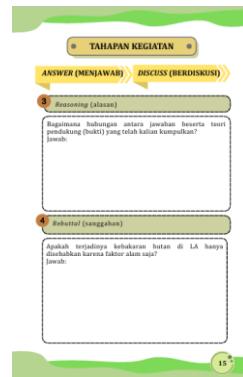


Figure 18. After Revision

Biology Teacher Assessment Results

The E-LKPD products were assessed by biology teachers at SMA Negeri 12 Semarang, assessing the appropriateness of the content, presentation, language, and media display. The biology teachers' assessment results are shown in Table 7 below.

Table 7. Biology Teacher Validation Results

No.	Aspect	Percentage	Criteria
1.	E-LKPD Display	100%	Very Valid
2.	Suitability of material content	100%	Very Valid
3.	Scientific argumentation skills	100%	Very Valid
4.	Language eligibility	91.6%	Very Valid
Overall percentage		98%	Very Valid

Based on the results of the biology teacher practitioner test, the percentage of material content and scientific argumentation skills was 100%, while the percentage of language adequacy was 91.6%. Therefore, the overall percentage was 98%, which means this E-LKPD product is very valid for use in biology learning.

Small Scale Student Test

The small-scale trial involved 34 students of grade X of SMAN 12 Semarang who were selected as samples using *purposive sampling techniques*. The field test stage was carried out in several steps, first, the researcher explained in advance about the E-LKPD product that had been developed, the researcher sent the E-LKPD link in the class group so that students could try to operate or use E-LKPD on their respective cellphones, then the researcher provided a readability questionnaire sheet for the developed E-LKPD. The results of the student readability test are in Table 8 below.

Table 8. Student Readability Test Results

No.	Aspect	Percentage	Criteria
1.	E-LKPD Display	89.1%	Very good
2.	Material	86%	Very good
3.	Linguistics	86%	Very good
4.	Graphics	90.4%	Very good
Overall percentage		88%	Very good

Based on the results of the readability test of class X SMA N 12 Semarang with a sample of 34 students, the percentage of the E-LKPD display aspect was 89.1%, the material aspect 86%, the linguistic aspect 86%, and the graphic aspect 90.4%, so that the overall percentage was 88% with a very good category. Therefore, this E-LKPD is considered very good for use in biology learning.

The teaching materials in the form of E-LKPD based on the RADEC learning model integrated with *Socio-Scientific Issue* to train scientific argumentation skills at the learning stage contain clear and systematic syntax. The components of the E-LKPD product include a cover, foreword, table of contents, concept map, user instructions, CP & TP, trigger questions, materials, stages of learning activities, learning reflections, and a bibliography. The learning activity stage uses the RADEC model integrated with *Socio-Scientific Issue*. The RADEC syntax consists of *read, answer, discuss, explain*, and *create* (Sopandi et al, 2021).

In the first syntax, namely *reading*, students can explore information from various sources, including books, journals, or other news (Sopandi et al., 2021). This syntax is also integrated with *Socio-Scientific-Issue*, which contains real issues in society related to scientific concepts that have social, ethical, or environmental impacts on each reading or news presented. This *reading activity* serves as the main foundation in building initial *claims* because students obtain important information from the issues discussed. In addition, this stage also helps students in collecting *evidence* in the form of data and empirical findings that can later be used to support or refute a *claim*. This is in line with the opinion (Sadler, 2011), that scientific literacy can help students understand complex and controversial issues in science (*Socio-Scientific Issues*) so they can construct arguments accurately.

The second syntax is *answering*, where students can answer questions presented according to scientific argumentation indicators such as claims, evidence, reasons, and rebuttals. At this stage, it is also combined with the third syntax, namely *discussing* (discussing) in groups by sharing evidence and presenting reasons that test the strength of each other's arguments, so that accurate answers are obtained. The collaboration between students in this discussion activity has the goal of improving students' argumentation (Sinambela et al., 2023). The *answer* and *discuss* stages are also integrated with *Socio-Scientific Issues*, which are divided into two types of questions with answers in the form of science and also social. Students must answer both questions based on scientific argumentation indicators such as *claims, evidence, reasoning, and rebuttals*.

The fourth syntax is " *explain*," where each group presents the results of their discussion by systematically presenting arguments, starting with answering *claims*,

strengthening *their reasoning, providing evidence*, and *rebuttal* to the audience. The audience can then provide rebuttals to each group's presentation. Therefore, student participation in argumentation helps them understand the importance of the relationship between evidence and claims, as well as the importance of justification in scientific argumentation (Fakhriyah et al., 2021).

The fifth syntax is *create*, where students can generate creative ideas or concepts in the form of works (Sopandi et al., 2021). The work created at this stage relates to indicators of scientific argumentation from the answers to previous questions in the form of claims, evidence, reasons, and rebuttals. This stage can train students to learn independently, creatively, and can contextualize a student's understanding of the material related to real life (Andriani et al., 2024). The RADEC syntax is integrated with *Socio-Scientific Issues* at each stage of the learning activities in this E-LKPD, which can train the scientific argumentation skills of grade X high school students.

Conclusion

Based on the results and data analysis of this study, the design of the development of E-LKPD based on the RADEC (*Read, Answer, Discuss, Explain, Create*) learning model integrated with *Socio-Scientific Issue* to train the scientific argumentation skills of grade X students was carried out using the *Research and Development method* with the *Define, Design, Develop, Disseminate* (4D) development model. The developed E-LKPD product contains a cover, foreword, table of contents, user manual, concept map, CP and TP, apperception, materials, stages of RADEC learning activities integrated with SSI, learning reflection, and bibliography. The validation results of the E-LKPD product were declared very valid by media experts (87.5%), material experts (97.2%), learning methodology experts (87.5%), scientific argumentation skills experts (90.6%), and biology teachers as practitioners (98%). The results of the readability test on the E-LKPD product showed an average value of 88% which is included in the very good category. Qualitative data showed a positive response. Students assessed that the E-LKPD has an attractive appearance, uses language that is easy to understand, and makes it easier for them in the learning process. Therefore, the RADEC-based E-LKPD integrated with SSI to train students' scientific argumentation skills is very valid and good to use in Biology learning.

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