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# Development of Electronic Student Worksheets Integrating Scientific Numeracy Literacy Content for Ecosystem Topics

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**Abstract**

Scientific and numeracy literacy are essential competencies for students in the 21st century, as they enable learners to interpret data, solve contextual problems, and apply scientific concepts in everyday life. However, Indonesian students continue to demonstrate relatively low achievement in these areas, partly due to the limited availability of learning resources that integrate numeracy literacy with science instruction, especially in biology topics such as ecosystems. Therefore, this study aimed to develop an electronic student worksheet integrating scientific and numeracy literacy content on the ecosystem subtopic. This study employed a Research and Development approach using the ADDIE model, which consists of analysis, design, development, implementation, and evaluation stages. The developed product was validated by three experts, while its practicality was assessed by three teachers and twelve students using Likert-scale questionnaires. The validation results showed that the electronic student worksheet achieved an average score of 91.42%, indicating a very valid category. In addition, the practicality test revealed scores of 88.79% from students and 96.35% from teachers, both categorized as very practical. These findings indicate that the developed electronic student worksheet is a feasible and practical learning resource for biology instruction. It also offers an innovative alternative for integrating scientific and numeracy literacy into ecosystem learning to better support students' competency development.

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## INTRODUCTION

The enhancement of educational quality is facilitated by advancing and innovating scientific knowledge. Quality human resources are born from quality education (Alberto et al., 2024; Mardhiyah et al., 2021). The rapid growth of knowledge and technology requires educational institutions to keep up with the times (Koseda et al., 2025; Reimers, 2024; Sewang, 2015). The learning process enables students to develop their potential and enhance their quality of life. Therefore, educators must consider various factors to improve the quality of education. These factors include clear learning objectives, relevant materials, a variety of learning methods, appropriate learning media, and accurate and objective evaluation (Faizah & Kamal, 2024; Gopalan, 2023).

One of the scientific fields in the learning process is biology. Biology is a complex subject with material presented as processes that are difficult to explain and relate to the natural world around us (Mathew, 2025; Rahioui et al., 2024; Syarah et al., 2021). The

ability of teachers to effectively utilize teaching materials and learning media is fundamental to the teaching and learning process. Teaching materials transform the teacher's role into that of facilitator, allowing more time to guide students in understanding the content through a variety of instructional methods rather than relying on lectures (Hidayati et al., 2024; Magdalena et al., 2020; Pratama, 2024). Integrating digital technology represents a potential strategy to increase the effectiveness of biology learning (Hakim, 2023; Suwono et al., 2023; Wang, 2025). Utilizing technology can make learning more interactive and participatory and encourage learners to increase knowledge rather than just being recipients of information.

One of the problems faced by teachers in learning is determining or choosing the right teaching or learning materials to help students achieve competence. Teaching materials can enable learners to understand and master all competencies as a whole and in an integrated way. Teaching materials can be defined as systematically organized resources that support independent learning and are developed in alignment with the applicable curriculum (Nuryasana & Desiningrum, 2020; Sidik et al., 2024). The use of teaching materials aligned with competency standards supports teachers in presenting learning content more coherently and systematically.

Providing teaching materials in the form of student worksheets that facilitate students' interaction with the content represents a viable solution (Muskaina et al., 2024; Pawestri & Zulfiati, 2020). Electronic student worksheets are learning resources consisting of task sheets, instructions for carrying out tasks, and learning evaluations that must be completed by students (Pawestri & Zulfiati, 2020; Poeck et al., 2025). In line with advances in science and technology and the transformation of learning during the COVID-19 pandemic, there is a need for more innovative student worksheets in digital formats, referred to as electronic student worksheets (Kholifahtus et al., 2021; Sofi-Karim et al., 2023; Zen et al., 2025). Electronic student worksheets are considered an appropriate solution due to their flexibility as teaching materials that accommodate the needs of teachers and students. Video displays, images, text, and questions in electronic student worksheets can be assessed automatically. The design of electronic student worksheets can be adjusted to the wishes and creativity of educators so that it can be interesting and learning becomes more optimal (Khotimah et al., 2026; Puspita & Dewi, 2021). Student worksheets have several components consisting of learning objectives, competencies to be achieved, supporting information, material, and also practice questions that can measure the ability of students (Destiansari et al., 2022; Widodo et al., 2023). This indicates a need for instructional materials that combine digital accessibility with competency-oriented learning design.

Indonesia is one of the countries with people who are classified as having low literacy skills, especially numeracy literacy. The PISA 2018 findings indicate that Indonesia ranks among the lower-performing countries in numeracy literacy, below Thailand. According to PISA 2018, Indonesia achieved an average mathematics score of 379, which is significantly below the OECD average of 489, placing Indonesia in the lower rank among participating countries (OECD, 2019). This suggests that the practical application of numeracy skills in daily life remains limited. Although students tend to master basic mathematical concepts, their ability to transfer this knowledge to real-life contexts is still inadequate. This low level of numeracy literacy is influenced by several factors, including the limited practice provided by teachers in engaging students with numeracy-based problem-solving tasks (Salvia et al., 2022; Santia et al., 2023).

Ecosystems are formed from a community and its abiotic environment, such as climate, soil, water, air, and energy, so that ecosystem material provides a response to a problem that exists in nature. Ecosystem material is one of the biological materials that is closely related to everyday life, which will arouse students' curiosity about what they find in nature. Learners will interact directly with their environment and solve problems that will be found

in everyday life. This research is supported by previous research from (Sari, 2019) about electronic student worksheets using 3D Pageflip Professional on science-based sound wave material using the wizer.me platform. Then continued with research (Zein & Musyarofah, 2024) regarding interactive electronic student worksheets using the wizer.me platform in social studies lessons. Hidayati (2023) developed science literacy-based student worksheets for ecosystem learning using printed formats, which were considered less engaging and less effective.

Previous studies have developed electronic student worksheets in various subjects and platforms; however, most studies primarily focused on media attractiveness and interactivity rather than the integration of scientific and numeracy literacy competencies ( Hidayati, 2023; Pawestri & Zulfiati, 2020; Widodo et al., 2023). In biology education, particularly ecosystem learning, limited studies have designed digital worksheets that engage students in interpreting ecological data, analyzing quantitative relationships, and solving contextual environmental problems. Therefore, instructional materials that combine digital accessibility with competency-oriented learning design are still needed (Destiansari et al., 2022; Muskaina et al., 2024).

Therefore, the novelty of this study lies not in the use of digital tools themselves, but in the pedagogical design of an electronic student worksheet that systematically integrates scientific and numeracy literacy into ecosystem learning activities. The worksheet is designed to help students connect ecological concepts with real-life quantitative situations through data interpretation, reasoning, and problem-solving tasks.

Based on the preceding discussion, through this integration, students are expected to develop problem-solving skills through scientific numeracy literacy. Therefore, this study aims to develop an electronic student worksheet based on science numeracy literacy for the ecosystem subtopic, with its feasibility assessed in terms of validity and practicality.

## METHODS

### Research Design

This research adopted the development research design utilizing the ADDIE model by Dick and Carey (2015), using five stages, namely Analyze, Design, Development, Implementation, and Evaluation (Kholonisa et al., 2023). However, this study was limited to the development phase, focusing on product validity and practicality as an initial stage prior to large-scale effectiveness testing. The research was conducted at Senior High School 18 Palembang and was limited to the development stage.

### Population and Sample

The development of electronic student worksheets was evaluated through small-group trials involving 12 students from class X E7, selected using a purposive sampling technique. Purposive sampling is a method in which participants are chosen based on specific criteria (Sugiyono, 2019). In addition to the students, three biology teachers who teach grade X were also included as participants. Class X E7 was selected as the trial sample based on the results of interviews with teachers at Senior High School 18, Palembang. According to the biology teacher of class X E7, this class demonstrates lower cognitive abilities compared to other classes, as indicated by consistently lower average scores. Furthermore, students in this class tend to be passive during the learning process.

### Instruments

The instruments used in this study included validation and practicality questionnaires. Prior to implementation, the electronic student worksheet was assessed through expert validation by material and media specialists. The validation results informed revisions to enhance the

product's validity and feasibility. The instruments were developed based on relevant indicators and followed a systematic process, including the identification of indicators based on relevant theories, item construction, and expert review. Content validity was established through expert judgment involving material, language, and media experts, who evaluated the relevance, clarity, and appropriateness of each item. The instruments were revised based on the feedback provided to ensure their suitability for measuring the intended constructs. The instruments were classified into material and media aspects, as presented in Table 1.

Table 1 Validation instrument grid for material, language, and media experts

| No | Validator | Aspect | No. Item |
|---|---|---|---|
| 1 | Media Expert | Design Quality | 1-8 |
| | | Usage Efficiency | 9-10 |
| 2 | Linguist | Readability and writing | 1-10 |
| 3 | Material Expert | Content/Material Quality | 1-7 |
| | | Learning Aspect | 8-14 |

Source: Modified from Safura et al. (2022) and Utami (2020).

The product's practicality was evaluated using questionnaire-based instruments administered to both teachers and students. The instrument grids for each group are shown in Table 2.

Table 2 Practicality instrument grid for teachers and students

| No | Aspect | No. Item |
|---|---|---|
| 1 | Practicality | 1-5 |
| 2 | Content/Material | 6-9 |
| 3 | Readability and Writing | 10-13 |
| 4 | Media quality | 13-15 |
| 5 | Benefits | 16-20 |
| 6 | Efficiency of use | 21-24 |

Source: Modified from Amalia et al.(2022) and Utami (2020)

The teacher and student practicality questionnaires consist of the same number of items and cover identical aspects. The reliability of the instruments was supported by the use of indicators adapted from previously validated instruments (Amalia et al., 2022; Utami, 2020) and through expert review to ensure consistency, clarity, and relevance of the questionnaire items. The practicality questionnaire consists of six aspects, namely practicality, content or material, readability, media quality, benefits, and efficiency of use.

**Data Analysis Technique**

The results and data obtained from validation by experts and questionnaire test limitations to obtain validity on electronic student worksheets are measured using a Likert scale.

Table 3 Likert scale scoring criteria

| Criteria | Score |
|---|---|
| Totally agree | 5 |
| Agree | 4 |
| Undecided | 3 |
| Disagree | 2 |
| Disagree | 1 |

The validation data and limited test responses that have been obtained are processed with the calculation formula below:

$$Value = \frac{total\ score}{maximum\ score}\ x\ 100\% \quad (1)$$

(Sugiyono, 2022)

Table 4 Conversion of validity

| Percentage (%) | Criteria |
|---|---|
| 81 – 100 | Very valid |
| 61 – 80 | Valid |
| 41 – 60 | Valid enough |
| 21 – 40 | Invalid |
| 0 – 20 | Invalid |

Source: Riduwan (2020)

The practicality of the electronic student worksheets was determined based on the results of response questionnaires completed by students and teachers. Analysis of the practicality of learners was obtained from small group trials. The practicality questionnaire of students and teachers was assessed using a Likert scale with the following formula:

$$Final\ score = \frac{Total\ score\ of\ data\ collection\ results}{maximum\ score}\ x\ 100\% \quad (2)$$

(Sugiyono, 2017)

Table 5 Conversion of electronic student worksheets practicality

| Percentage (%) | Criteria |
|---|---|
| 81 – 100 | Very practical |
| 61 – 80 | Practical |
| 41 – 60 | Practical enough |
| 21 – 40 | Not practical |
| 0 – 20 | Not very practical |

Source: Sugiyono (2017)

The data in this study consisted of qualitative and quantitative types. Qualitative data were derived from curriculum analysis, need analysis of students and teachers, analysis of learning objectives, and expert feedback obtained through material, language, and media validation. Meanwhile, quantitative data were obtained from product assessments based on validation questionnaires administered to several experts, including material, language, and media experts. In addition, data were obtained from teacher and learner practicality questionnaires. The instruments used are a product validity questionnaire administered to three validators and practicality questionnaires for participants and teachers.

Data analysis in this study employed descriptive statistics to determine the validity and practicality of the developed electronic student worksheet. Reliability testing using statistical measures was not conducted, as this study was limited to the initial stage of product development. Data analysis was conducted to evaluate the feasibility and practicality of the electronic student worksheet for biology learning, based on students' responses. The practicality assessment was guided by questionnaire items rated on a Likert scale from 1 to 5.

**Research Procedures**

The ADDIE model was implemented in this study. First, in the analysis stage, interviews with students and biology teachers were conducted to explore initial classroom conditions, including the teaching materials used, instructional approaches, students' learning

difficulties, and the curriculum implemented. Interviews were conducted with 12 students and 3 biology teachers. Second, during the design stage, electronic student worksheets were developed using Canva. The research procedure based on the ADDIE model is shown in Figure 1.

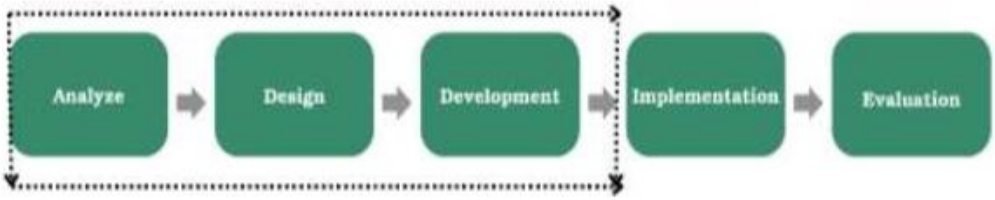



Figure 1 Research procedure based on the ADDIE model

The design outputs were integrated into the Liveworksheets platform, with additional elements incorporated into the electronic student worksheets, including short-form fields, learning video links from YouTube, website links, and information barcodes. These were integrated into the electronic student worksheets to facilitate students' access to and completion of tasks without requiring external applications, and to provide additional information from videos and websites via barcodes. Third, during the development stage, the electronic student worksheet products are validated by three validators: material experts, language experts, and media experts. After validation, improvements were made based on the three validators' suggestions and input. The electronic student worksheets were revised in accordance with the suggestions, feedback, and assessments provided by expert validators to ensure their validity and appropriateness for use. Following validation, the science, numeracy, and literacy-based electronic student worksheets were tested with students to evaluate their alignment with learning objectives and their effectiveness in supporting the learning process. The trial was conducted with a small group of 12 tenth-grade students. Students' responses were collected using a practicality questionnaire, which was also administered to three biology teachers.

## RESULTS AND DISCUSSION

This study resulted in the development of a science-numeracy-literacy-based electronic student worksheet to support students' critical thinking and problem-solving skills, delivered via the LiveWorksheets platform. The product was evaluated by three expert validators (material, media, and language), and user responses were collected from both students and teachers through questionnaires.

Senior High School 18 Palembang applies the Merdeka Curriculum for grades X and XI. Within this curriculum, ecosystem content is categorized under Phase E. By the end of this phase, students are expected to understand the classification of living organisms and the roles of viruses, bacteria, and fungi in life; ecosystems and interactions between components and influencing factors; and the use of biotechnology in various fields of life. Learners understand the measurement system in scientific work and alternative energy and its utilization to solve energy availability problems. Learners understand atomic structure and its relation to the properties of elements in the periodic table; and understand chemical reactions, basic laws of chemistry, and their role in daily life. Learners apply science understanding to address issues related to climate change. Learners are further developed through the integration of process skills, scientific attitudes, and the Pancasila Student Profile. Ecosystem material is delivered in the first semester of the 2024/2025 academic year.

Findings from interviews with three biology teachers indicate that electronic student worksheets are infrequently used in classroom practice due to the time-consuming nature

of their development. As a result, teachers predominantly use printed books, YouTube videos, and PowerPoint slides as instructional materials. In interviews, students feel that printed books are less interesting and less interactive to use. In PowerPoint presentations, the teacher only relies on slides, so they are still less interesting and boring. Meanwhile, the use of YouTube videos, without integration with other learning media, may lead to one-way interaction, which may limit students' understanding of the learning material. Research conducted by Amanullah & Wiharja (2022) states that YouTube videos can only provide one-way interaction. Research conducted by Yunus & Fransisca (2020) stated that students find it easier to remember things that are seen, read, and done.

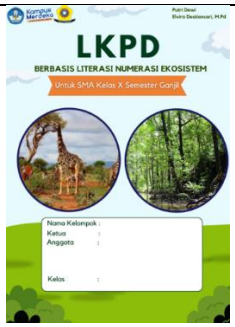
The results of the interviews suggest that teachers have not yet fully developed the knowledge and skills required to effectively use technology to develop instructional materials. The electronic student worksheets to be designed will include information and videos on science, numeracy, and literacy, integrated into related QR codes to make them more interesting and interactive. At the problem presentation stage, students can directly access the information text and graphics without using additional applications. Automatic assessment can make it easier for teachers and make time more efficient. Thus, electronic student worksheets grounded in numeracy literacy were developed to foster interactive learning, provide feedback, and enable students to address problems in real-life contexts. Needs analysis for students and teachers is very important in order to obtain data that suits the needs related to learning aspects (Farihat et al., 2024; Mubarok et al., 2024).

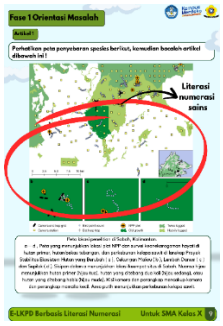
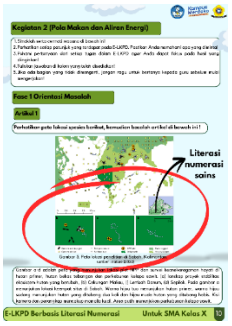
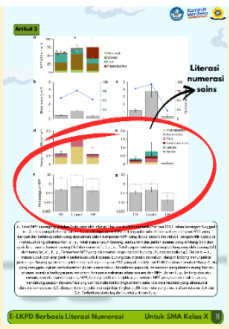
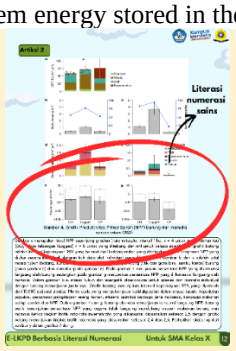
The learning objectives are aligned with the learning outcomes and science, numeracy, and literacy indicators. The learning objectives are divided into three meetings based on ecosystem sub-materials: biotic and abiotic components; patterns and energy flows; and biogeochemical cycles and ecosystem imbalances. Learning objectives were formulated by considering the school's current instructional practices, the design of the electronic student worksheets, and students' needs derived from interview results. The material analysis stage is conducted to identify the content to be included in the electronic student worksheets. In this analysis, learning outcomes serve as the reference for determining indicators. The material analysis stage is conducted to demonstrate the material's suitability. To explain the concept correctly, the material presented is systematic and contains important concepts that students need to know (Alias, et al., 2023; Bajwa et al., 2025; Costadena & Suniasih, 2022). Based on interviews with teachers, the ecosystem topic focuses on biotic and abiotic components, diet and energy flow, biogeochemical cycles, succession, and environmental change. The five main materials: students still do not master the sub-materials on food patterns, energy flows, and biogeochemical cycles. Students indicated that they find the material difficult to comprehend due to its complexity and the use of text-heavy, insufficiently engaging textbooks.

At the design stage, the electronic student worksheets based on science, numeracy, and literacy for ecosystem subtopics were developed using the Canva application. The design of the electronic student worksheets has several parts, such as a cover, content, and a back cover. The design of the electronic student worksheets is based on the PBL syntax and numeracy-literacy base, which aims to solve problems in the surrounding environment using graphs, symbols, and data, both independently and in groups. The design of the electronic student worksheets, based on science, numeracy, and literacy, was developed using Canva and aligned with the numeracy-literacy-based PBL stages: problem orientation, organizing students, guiding investigation, presenting work, and evaluating the problem-solving process. These stages support the development of higher-order thinking skills, including critical thinking, creativity, and problem-solving. Continuous practice enables students to apply and improve their mathematical literacy skills (Astuti, 2018; Hidayati et al., 2025; Supianti et al., 2025; Susanta et al., 2025).

At the development stage, the electronic student worksheets conceptualized during the design phase were subsequently reviewed and validated by three expert validators (lecturers). The products were assessed by material, language, and media validators. The material validators evaluated aspects related to content quality and instructional relevance. Language validators focused on readability and writing quality. Meanwhile, media validators assessed design quality and usability efficiency. During the validation process, the product that has been designed will be assessed by the validator. The product will be given suggestions and input by the validator in order to be improved and refined so that it is valid and can be used. Electronic student worksheet products that have been designed and have been improved based on input and suggestions from validators can be seen in Table 6.

Table 6 Electronic student worksheets enhancements following validator evaluation

| Before revision | After revision |
|---|---|
|  (1) |  (2) |
| The color on the cover is too striking; the picture on the cover does not represent the ecosystem material and is broken; the identity column is too large and takes up space. | The color on the cover is more appropriate, the picture already represents the ecosystem material and is more interesting, and the identity column is more reduced. |
|  (3) |  (4) |
| Learning objectives are not in line with learning indicators and science numeracy literacy has not been included. Objectives are not separated per activity. | Learning objectives are in line with the learning indicators and have included science numeracy literacy. Learning objectives have been made per activity. |
|  |  |

| Before revision | After revision |
|---|---|
| (5) | (6) |
| The color in the text column of the discourse is too bright, making it hard for the eyes to read, and a barcode has not been added to access the information in the discourse. The video of the desert ecosystem is not aligned with the discourse of the mangrove forest ecosystem. Presentation of problems in activities 1 articles 1 and 2 based on science literacy regarding abiotic biotic components in mangrove forests. | The color of the discourse text column has been changed to white so that the eyes are not too tired when reading. Barcodes to access information and videos have been added, the video is changed to a video of the mangrove forest ecosystem to be in harmony with the discourse so that students immediately understand the purpose of the discourse and video. Presentation of problems in activities 1 articles 1 and 2 based on science literacy regarding abiotic biotic components in mangrove forests. |
|  |  |
| (7) | (8) |
| There are no instructions for using each activity, the images are too large, the layout is not appropriate and the image captions have not been analyzed. Activity 2 of article 1 is based on science numeracy literacy because it analyzes a map of the research location in Sabah, Kalimantan. | Instructions for use have been added to each activity, map images have been adjusted and map image descriptions have been analyzed so that students are easy to understand the information conveyed. Activity 2 article 1 is based on science numeracy literacy because it analyzes the map of the research location in Sabah, Kalimantan and analyzes the ecosystem energy stored in the forest. |
|  |  |
| (9) | (10) |
| The language and sentences in the article have not been analyzed as a whole so there are several sentences that make readers less familiar with the information conveyed. In activity 2, article 2 uses a science numeracy literacy base because students are required to analyze bar graphs regarding the net primary productivity (NPP) of birds and mammals. | The language and sentences in the article have been analyzed as a whole so that readers understand the information conveyed better. In activity 2, article 2 uses a science numeracy literacy base because learners are required to analyze bar graphs regarding the net primary productivity (NPP) of birds and mammals. |

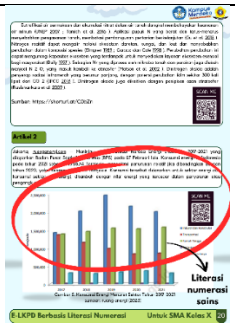
| Before revision | After revision |
|---|---|
|  |  |
| (11) The link is too long and the information source barcode has not been added. The problem orientation in activity 3 of article 2 uses a science numeracy literacy base because students are required to analyze a bar chart of energy consumption in Indonesia from 2017-2021. | (12) The link has been shortened and the source barcode added. The problem orientation in activity 3 article 2 uses a science numeracy literacy base because learners are required to analyze a bar chart of energy consumption in Indonesia from 2017-2021. |
|  |  |
| (13) E-LKPD assessment is still used as one, not yet separated per activity and the background of the assessment is not yet appropriate | (14) E-LKPD assessments have been separated according to the activity and the background of the assessment has been adjusted to make it more attractive. |

Figure 2 Electronic student worksheets improvements based on expert validator suggestions and input before and after Revision (1-2) cover, (3-4) learning objectives, (5-6) phase 1, (7-8) phase 2, (11-12) phase 4, (9-10) phase 1 activity 2, (11-12) phase 1 activity 3, (13-14) E-LKPD assessment

The products that have been made are then assessed by validators using an assessment instrument adapted and modified from Safura et al. (2022) and Utami (2020). A summary of the validation score calculations, as provided by the three validators, appears in Table 7.

Table 7 Material, language, and media validation outcomes for the electronic student worksheet based on scientific numeracy literacy

| No | Aspect | Total Score | Maximum Score | Percentage (%) | Criteria |
|---|---|---|---|---|---|
| 1 | Material | 66 | 70 | 94.28 | Very valid |
| 2 | Language | 48 | 50 | 96.00 | Very valid |
| 3 | Media | 42 | 50 | 84.00 | Very valid |
| | | **Average** | | **91.42** | **Very valid** |

Based on the calculation of the validation results with a Likert scale, an average of 91.42% is obtained, according to Table 7. Therefore, electronic student worksheets based

on science, numeracy, and literacy on ecosystem sub-materials can be used and tested because they are in a very valid category with an average value of 91.42%.

Electronic student worksheets that have received suggestions and been entered by material, language, and media validators are then assessed using a validation questionnaire. The validation results are then calculated on a Likert scale, and the results are interpreted to determine the product's criteria or category. The results of the calculation of product validation obtained an average percentage value of 91.42%, meaning that the product that has been developed falls into a very valid category. This result aligns with the research conducted by Rahmita et al. (2024), which obtained an average score of 89.25%, indicating a very feasible category. This finding is consistent with the study by Mairani et al. (2022), which reported an average score of 96.82%, categorized as very feasible. It is further supported by Syahputri et al. (2023) who obtained an average result on the material aspect of 83.91% and media 91.17% with a very valid category. In addition, Asnawi et al. (2023) reported an average percentage of 88.8% with a very valid category. Similarly, Meilani et al. (2024) found an average 89% indicating very valid category. Based on these evaluation results, the ecosystem subtopic electronic student worksheet based on science, numeracy, and literacy can be categorized as very valid and appropriate for use as teaching material. These findings are further strengthened by evidence from previous studies.

After the validation process, the researcher revised and refined the product based on the suggestions and feedback provided by the three validators, namely material, language, and media experts. The product evaluation involved these three types of validators, and the revisions made are presented in Table 7. These improvements were carried out to identify and address the shortcomings encountered during the product development process, as well as to recognize the difficulties and constraints faced. Through this validation and revision process, the researcher enhanced the product's quality, ensuring it is appropriate for use and beneficial for its intended purpose.

Products that have been declared valid by material, language, and media experts are subsequently tested with a small group of 12 students. This trial aims to examine students' responses regarding the practicality of the developed electronic student worksheets. The data were collected using a practicality questionnaire administered after students had completed using and working with the worksheets. The results of the practicality assessment of the electronic student worksheets are presented in Table 8.

Table 8 Results of the practicality questionnaire for scientific numeracy literacy-based electronic student worksheets in small group trials

| No. | Aspect | Obtained Score | Maximum Score | Percentage (%) | Criteria |
|---|---|---|---|---|---|
| 1 | Practicality | 262 | 300 | 87.33 | Very practical |
| 2 | Content/Material | 214 | 240 | 89.16 | Very practical |
| 3 | Readability and Writing | 213 | 240 | 88.75 | Very practical |
| 4 | Media quality | 162 | 180 | 90.00 | Very practical |
| 5 | Benefits | 271 | 271 | 90.33 | Very practical |
| 6 | Efficiency of use | 157 | 157 | 87.22 | Very practical |
| **Average** | | | | **88.79** | **Very practical** |

In addition to students, the practicality questionnaire was also administered to the Biology teacher to assess the practicality of developing electronic student worksheets from the teachers' perspective. The results of the teachers' practicality questionnaire are presented in Table 9.

Table 9 Result of the practicality questionnaire for scientific numeracy literacy based electronic student worksheets by teachers

| No | Aspect | Obtained Score | Maximum Score | Percentage (%) | Criteria |
|---|---|---|---|---|---|
| 1 | Practicality | 71 | 75 | 94.67 | Very practical |
| 2 | Content/Material | 59 | 60 | 98.33 | Very practical |
| 3 | Readability and Writing | 58 | 60 | 96.66 | Very practical |
| 4 | Media quality | 45 | 45 | 100 | Very practical |
| 5 | Benefits | 73 | 73 | 97.33 | Very practical |
| 6 | Efficiency of use | 41 | 41 | 91.11 | Very practical |
| **Average** | | | | **96.35** | **Very practical** |

The developed scientific numeracy literacy based electronic student worksheets is a teaching material that includes subtopics on biotic and abiotic components, food patterns and energy flows as well as biogeochemical cycles and ecosystem imbalances. There are three indicators of science numeracy literacy according to Limiansih & Susanti (2021) and Han et al. (2017) each of which has been included in the making of materials and questions in the electronic student worksheets. Science numeracy literacy indicators have been incorporated into the learning objectives of the ecosystem sub-material. The developed electronic student worksheet is designed based on science numeracy literacy, as it integrates various content elements such as information text, maps, numbers, symbols and diagrams in it in accordance with science numeracy literacy indicators and learning outcomes in phase E to help students understand science and numeracy concepts. The problems and questions contained in the science numeracy literacy-based electronic student worksheets relate to everyday life to improve learners' understanding of the problems. The integration of real life contexts and environmental surroundings in learning can enhance students' experiential understanding (Alm et al., 2022; Demssie et al., 2023; Gambo & Muhammad, 2023; Mettis et al., 2023; Sari et al., 2023).

The students' practicality sheet includes six aspects. The results showed an overall practicality percentage of 88.79%, which falls into the very practical category. This score indicates that the developed electronic student worksheets are easy to use and highly practical for implementation during the learning process. Beyond indicating usability, this finding suggests that the worksheet design supports student engagement and facilitates active interaction during learning activities. These findings are consistent with previous studies by Elisabet et al., (2024) reported a practicality score of 86.6% in the development of Problem Based Learning (PBL)-based electronic student worksheets on the topic of surface area, categorized as very practical. This research, in line with Lase & Zai (2022), obtained a result of 87.5%, also classified as very practical. Supporting evidence is also provided by Asnawi et al., (2023) which reported average percetages of 80% in small group trials and 83.33% in large group trials. Furthermore, Farzana et al. (2024) reported an average percentage of 85.7%, categorized as very good. However, unlike previous studies that mainly emphasized usability and interactivity, the present study highlights the integration of scientific and numeracy literacy within the worksheet, which adds pedagogical value beyond technical practicality.

In terms of specific aspects, the content or material aspect achieved a percentage of 89.16%, indicating that the content of the electronic student worksheets is well aligned with the ecosystem subtopic. This alignment is important because learning becomes more meaningful when instructional materials are contextually relevant and connected to real-life situations, as emphasized in constructivist learning theory. The readability and writing aspect obtained a percentage of 88.75%, categorized as very practical. This suggests that the language used in the worksheets is clear, easy to understand, and appropriate in terms

of font type and size, making the material comfortable and accessible for students to read. Readability in the electronic student worksheets is essential to ensure that students can effectively comprehend the discourse and informational texts presented within the material (Cahyani et al., 2024; Evans & Ailie, 2022; Kirchner et al., 2023; Widodo et al., 2023). In addition, good readability can reduce students' cognitive load, allowing them to focus more on understanding concepts rather than decoding information.

The media quality aspect obtained a percentage of 90% with a very practical category, which shows that electronic student worksheets have an attractive appearance and design so that students become more interested in using electronic student worksheets in the learning process. Interesting and interactive teaching materials can improve the ability and understanding of students in understanding the material (Margareta, 2021; Rachmawati et al., 2026; Sinaga et al., 2022). From a theoretical perspective, this supports multimedia learning theory, which suggests that combining visual and textual elements can enhance students' understanding when properly designed.

The benefit aspect obtained a percentage of 90.33% in the very practical category, indicating that the use of electronic student worksheets provides many benefits for students in the learning process. These worksheets support learners in developing greater independence and active participation during learning activities. In addition, it can improve students' ability to solve more problems and add insight. Electronic student worksheets are therefore considered essential and beneficial as teaching and practicum materials, as well as effective solutions to overcome monotonous learning, in line with the demands of 21st-century education (Muttaqiin et al., 2024; Suryaningsih & Nurlita, 2021; Winarto et al., 2025). In addition, electronic student worksheets are effective in promoting students' learning independence, facilitating the learning process, stimulating the active role of students in learning, and enhancing motivation and interest in learning (Sariani & Suarjana, 2022; Yahiaoui et al., 2022; Irdalisa et al., 2024). This indicates a shift toward student-centered learning, where learners actively construct knowledge through guided tasks rather than passively receiving information.

In terms of efficiency of use, the product obtained a percentage of 87.22%, which is a very practical category, showing that the discourse website link included can be accessed easily and smoothly. The videos presented can be accessed without additional applications, so that the overall secure electronic student worksheets are easy to access and use by students during the learning process. In addition, students can access electronic student worksheets anytime and anywhere other than during school learning. This flexibility reflects the characteristics of digital learning environments that support independent and continuous learning beyond classroom boundaries. Overall, the electronic student worksheets achieved an average score of 88.79%, categorized as very practical across all assessed aspects. These findings are supported by Syahputri et al. (2023), who reported a student practicality response of 86.66%, also within the very practical category with positive comments and suggestions. Furthermore, the results of the teachers' practicality questionnaire showed an average percentage of 96.35%, indicating a very practical category for all aspects. This is consistent with the study by Elisabet et al. (2024), which reported a teacher practicality score of 89.2%, also classified as very practical. Additional support is provided by Lestari et al. (2018) further emphasize that the practicality of student worksheets is determined by their ease of use, contribution to time efficiency in learning, attractiveness, and usefulness. Practicality is used to assess the level of usability of a product, including its ease of understanding and the degree of user satisfaction experienced by teachers and students in educational contexts (Cahaya et al., 2024; Dutta et al., 2022; Li et al., 2022; Sulisworo et al., 2022).

The integration of science, numeracy, and literacy within electronic student worksheets enables students to independently solve problems encountered in everyday life. Therefore, its alignment with the Problem-Based Learning model can enhance students' problem-solving skills. This finding is supported by Saputro et al. (2024), who indicate that numeracy literacy skills significantly influence problem-solving abilities, particularly in mathematical contexts. The concept of numeracy literacy not only has a relationship with mathematical concepts but also relates to nonmathematical concepts such as social, science, economic, and even citizenship, which means that numeracy literacy skills must pay attention to the integration of learning materials. Numeracy literacy supports learners in addressing real-life problems through the use of reasoning and diverse knowledge, allowing them to make well-informed decisions accompanied by logical explanations (Munahefi et al., 2023; Reyna & Charle, 2023; Santia et al., 2023; Yerizon et al., 2025). Through science, numeracy, and literacy skills, students are able to achieve a high level of competence, particularly in problem-solving abilities. This finding highlights the importance of integrating numeracy within science learning rather than teaching it as a separate skill, as real-world problems require interdisciplinary understanding. The habit of using a set of numbers and symbols in categorizing problems in tabular form so that it is easy to read and understand is part of numeracy literacy (Ardiawan et al., 2024; Rachmawaty et al., 2026; Rahma & Reflina, 2023; Sinaga et al., 2022).

The use of science numeracy literacy-based electronic worksheets is relevant for ecosystem learning, since the concepts are directly associated with real-life phenomena experienced by students. Through electronic student worksheets based on science, numeracy, and literacy in the developed ecosystem sub-chapter material, it is expected to help students understand the sub-chapter material well. Understanding the ecosystem sub-material well will enable students to participate by providing solutions and efforts in reducing the ecosystem imbalance that occurs. Numeracy literacy skills are not only beneficial for schools and the environment, but can be useful for students themselves to improve human resources and strengthen thinking about mathematics and how to solve it in everyday life (Gizaw & Solomon, 2024; Pratiwi et al., 2023).

This finding is important because it demonstrates that learning materials designed with integrated scientific and numeracy literacy can bridge the gap between conceptual understanding and real-world application. Rather than learning ecosystem concepts in isolation, students are encouraged to interpret data, analyze relationships, and apply quantitative reasoning to environmental issues. This indicates that the developed worksheet supports not only content mastery but also higher-order thinking skills, particularly in problem-solving and decision-making (OECD, 2019; Santia et al., 2023).

Furthermore, integrating numeracy literacy into ecosystem learning provides meaningful learning experiences, as students engage with authentic problems such as environmental imbalance, resource distribution, and ecological interactions. This is consistent with recent studies emphasizing that contextual and integrated learning approaches improve students' understanding and application of scientific concepts (Munahefi et al., 2023; Yerizon et al., 2025). Therefore, the significance of this study lies in its contribution to designing instructional materials that connect biology concepts with quantitative reasoning in a contextual and applicable manner.

Based on the research conducted, the development of electronic student worksheets on the ecosystem subtopic, grounded in science, numeracy, and literacy, is carried out in several stages, starting with analysis, design, and development. The three stages are carried out sequentially and adjusted to the indicators of science numeracy literacy. The integration of numeracy literacy is intended to foster students' critical thinking and their ability to relate mathematical problems to everyday contexts.

## CONCLUSION

This study concludes that the development of a scientific numeracy literacy-based electronic student worksheet on the ecosystem subtopic has produced a valid and practical learning resource. The product achieved a high validity score of 91.42% based on expert evaluation and demonstrated high practicality, with scores of 88.79% from students and 96.35% from teachers. These findings indicate that the development of electronic student worksheets has the potential to support the integration of scientific numeracy literacy into biology learning, particularly in ecosystem contexts closely related to real-life phenomena. This study contributes to science education by providing a model of instructional material that integrates scientific concepts with numeracy skills in a contextual ecosystem-based learning environment. Practically, it offers an alternative digital resource to support student-centered and competency-based learning. However, this study is limited to the development stage and a small-group trial. Therefore, further research is needed to examine its effectiveness in broader educational settings.

## CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

## AUTHOR CONTRIBUTIONS STATEMENT

Conceptualization, PD, ED, and SAS; METHODOLOGY, PD, ED, and SA; Formal analysis, PD, ED, and PS; Writing—preparation of the original draft, PD, ED, SA, and PS; and others.

## AI DISCLOSURE STATEMENT

The authors declare that this research was prepared, researched, written, and edited without the aid of artificial intelligence (AI) techniques.

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