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Enhancing Students' Argumentation and Reflective Judgment in Biology learning through LMS based on Socio-Scientific Issues

Edysyah Putra[1]*, Dinda Vebrina[1]

[1]Institut Pendidikan Tapanuli Selatan, Sumatera Utara, Indonesia

* Corresponding Author. E-mail: edysyahputra.ipts@gmail.com

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Abstract: This study aims to develop a biology learning device based on socio-scientific issues (SSI) assisted by a learning management system (LMS). It employs the ADDIE development model, which consists of the stages of Analysis, including needs analysis, initial and final analysis, Design, Development, Implementation, and Evaluation. The research subjects consisted of one material expert, one media expert, and 36 high school students. Data were collected using assessment instruments and questionnaires to obtain reviews and recommendations from experts on the developed biology learning device. Based on data analysis from the assessment results of two validators, the average score (PRS) of biology learning devices in the aspect of biological study information is 80 (high), the aspect of learning organization is 82 (high), the aspect of web/LMS operational presentation is 82 (high), and the aspect of biological study language is 84 (high), thus making the overall average of 82.29 (high). From the PRS results obtained, it can be concluded that the LMS biology learning device based on SSI to improve the argumentation and reflective judgment skills of high school students meets the validity aspect and can be implemented in high school students' biology learning.

Keywords: argumentation, biology learning tools, LMS, reflective judgment, SSI

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INTRODUCTION

The world of education in the 21st century is currently facing the challenge of rapidly developing synergy with the increasingly comprehensive world of science, the era of globalization, and the integration of technology into education. In facing these challenges, teachers must be so well prepared that students have good competence, especially in science and technology literacy, and can think critically, logically, creatively, and collaboratively (Yılmaz, 2021). The 21st-century learning experience involves a shift in the learning paradigm, especially from the teaching paradigm to the learning paradigm, due to the complexity of the competencies that students must master. The teaching that used to be teacher-centered now should be student-centered. Teachers now play a greater role as facilitators of the learning process, no longer as exclusive sources of knowledge (Kivunja, 2014).

The teaching and learning process carried out in schools has two elements that are very important for success in achieving learning goals. These two elements are teaching methods and learning media (Puspitarini & Hanif, 2019). Teaching methods and learning media are related to each other. The choice of teaching methods can affect the type of learning media used, although several other aspects must be considered, such as teaching objectives, type of assignment, and student responses after teaching takes place. However, one of the important functions of learning media is as an aid in learning which also affects the conditions, situations, and atmosphere of learning created by the teacher.

The use of learning media in the teaching and learning process can arouse new desires and interests, arouse motivation, stimulate learning activities, and even bring psychological effects to students (Taha & Abdulrahman, 2023). Therefore, the use of learning media in learning activities is very

important and helps teachers to achieve educational goals. The educational goals that teachers are expected to achieve follow the goals of national education in the Constitution of 1945 concerning education as stated in Law No. 20, 2003. Article 3 states, "National education functions to develop abilities and shape the character and civilization of a dignified nation to educate the life of the nation, aims to develop the potential of students to become human beings who believe in and fear God Almighty, have a noble character, are healthy, knowledgeable, capable, creative, and independent to become democratic and responsible citizens."

Science education (IPA) is expected to be a vehicle for students to learn about themselves and the environment, as well as prospects for further development in applying it in everyday life. Science learning is expected to foster the ability to think, work, and behave scientifically and communicate it as an important aspect of life skills (Mann et al., 2022). One of the important abilities to be developed in students in science learning activities is scientific argumentation; by arguing scientifically students can express ideas or concepts that can show the relationship between the results of thinking and real evidence in science (Putri et al., 2020).

Allchin & Zemplén (2020) define argumentation as an attempt to validate or refute a claim based on reasons in a way that reflects scientific values. A claim, in this context, is not just an opinion or idea. A claim is an assumption, explanation, or conclusion that provides an answer to a research question. Meanwhile, Sandoval et al (2019) state that argumentation is a form of rhetoric that seeks to influence the attitudes and opinions of others so that they believe and ultimately act according to what the writer or speaker wants. In presenting an argument, a person must collect facts in such a way that he can show that an opinion or something is true or not through argumentation. So the basis of an argumentative opinion is thinking and being logical.

Argumentation contribution to science learning in the classroom can be grouped into five dimensions. The first dimension is the argumentation supports the existence of cognitive and metacognitive processes according to the performance characteristics of experts who can be models for students (Yılmaz, 2021). The second dimension supports the development of communication and critical thinking competencies. The third dimension supports the achievement of scientific literacy and trains students to speak and write using the language of science. The fourth dimension supports enculturation into scientific cultural practices and develops epistemic criteria for evaluating knowledge. The fifth dimension supports the development of reasoning, especially in selecting theories or determining attitudes based on rational criteria. One of the strategies that is alternative to improving argumentation skills is the socio-scientific issues (SSI) learning strategy (Paulins & Moeller, 2017)

The SSI learning strategy is a learning strategy that presents science material in the context of social issues by involving moral or ethical components (Chen & Xiao, 2021). Socio-scientific issues (SSI) are open-ended issues both conceptually and procedurally related to science and have the possibility of rational solutions that can be influenced by social aspects such as cultural identity, politics, economy, and ethics (Owens et al., 2021). The involvement of social aspects in SSI provides an opportunity for the emergence of conflict between scientific reasoning and social perspectives, which in learning has great potential for the development of moral reasoning, argumentation, and reflective judgment skills (Herlanti et al., 2023) to solve problems related to issues.

Reflective judgment as one of the targets of student abilities that can be developed through SSI-based learning is the ability to think critically and reflectively to make decisions and solve problems based on certain considerations (Antonio, 2020). Through reflective judgment, students can assess claims of opinion, analyze the basis of arguments, and measure their perspectives on socio-scientific issues presented (Zeidler et al., 2009). Reflective judgment shows the level of literacy development of a person in terms of the ability to collect and analyze data from various sources and use it as a basis for making responsible decisions (Callahan, 2009), consisting of seven levels of ability grouped into three categories, namely pre-reflective, quasi-reflective, and reflective categories (Aisya et al., 2017).

This study offers a significant contribution to the field of education by developing a biology learning device based on socio-scientific issues (SSI) through a learning management system (LMS**)**, focusing on enhancing students' argumentation and reflective judgment skills. The integration of SSI into biology education introduces new dimensions by presenting relevant sustainability issues, which not only deepen students' understanding of science but also sharpen their critical thinking skills. The use of LMS enables more structured and flexible learning management, providing easy access to materials, discussions, and comprehensive assessments. Furthermore, this research differentiates itself by focusing

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on two key skills argumentation and reflective judgment simultaneously developed within the context of SSI-based learning, an approach not extensively explored in previous biology education research. Thus, this study not only introduces an innovative learning approach but also makes a tangible contribution to shaping a generation that is more critical and reflective, capable of effectively linking sustainability issues with scientific problem-solving.

The pre-research interviews that have been conducted with biology subject teachers at one of the high schools in South Angkola show that their school has never used SSI-based learning devices assisted by LMS because when they teach biology, conventional teaching methods are still often used so learning activities are less student-centered. From this description, the researchers are interested in researching the development of SSI-based biology learning devices assisted by LMS to improve high school students' argumentation and reflective judgment skills. The problem in this study is formulated as follows: How is the LMS for SSI-based biology learning device to improve high school students' argumentation and reflective judgment skills developed?

METHOD

This research and development adopted the ADDIE (analysis, design, development, implementation, and evaluation) model (Sugiyono, 2015) up to the development stage considering the limitations of the research. It was conducted at SMA N 1 Angkola Selatan from March to September 2024.

The subjects of this research include lecturers who are experts in biology material and lecturers who are experts in biology learning media as validators, high school biology teachers as subjects of product readability tests, and grade X high school students as respondents. In detail, the research subjects consist of one biology lecturer with environmental topics, one biology education lecturer who is an expert in developing biology media and teaching materials, and one biology teacher who teaches at South Angkola High School.

Data was collected through expert evaluations and a questionnaire. Experts, including validators and biology teachers, assessed the developed learning media for its suitability. Their evaluations covered content accuracy, learning structure, LMS usability, and language clarity. A questionnaire further gathered their feedback on the media's effectiveness. The data obtained consists of qualitative information, including suggestions, notes, and comments provided on the assessment sheets of the learning web media. The data were subjected to descriptive qualitative analysis to inform revisions for the further development of the biology learning web media. The results of the media feasibility assessment were measured using the Likert Scale, which was subsequently translated into quantitative terms following a structured procedure. This study used a questionnaire that contained five types of answers in each item. The data are presented in Table 1.

Table 1. Answer Score

No	Score	Category
1	5	Very good
2	4	Good
3	3	Fair
4	2	Poor
5	1	Very Poor

Then percentage of eligibility was calculated using the following formula. The calculation results were used to determine the feasibility of the media. The classification was divided into five categories on a Likert scale. Table 3 presents a division of the range of media feasibility categories according to Arikunto (2009).

$$\% \text{ Eligibility} = \frac{\text{Total Score}}{\text{Maximum Score}} \times 100\%$$

The validity analysis of the feasibility was carried out by descriptive percentage analysis by determining the Average Percentage Score (PRS) of the achievement of each component of the validated

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aspect. Component achievement categories in percentage interpreted in very good criteria⇔90≤*PRS*≤100, good⇔80≤*PRS*<90, fair⇔70≤*PRS*<80, poor⇔60≤*PRS*<70 and very poor⇔0≤*PRS*<60 (Sudjana, 2007). A validated component meets the valid criteria if *PRS*≥70 or at least in the sufficient category. The validator's assessment of the developed textbook (product) is also accompanied by suggestions and comments from the validator. The suggestions and comments from the validator were analyzed qualitatively to implement the suggestions or comments submitted by the validator to revise the developed textbook. Based on the suggestions and comments given, improvements were made to the textbook that had been prepared. The suggestions submitted by the validator were analyzed so that they became suggestions that supported and built on improving learning devices (Istiqamah, 2019).

RESULTS AND DISCUSSION

This research is research and development (R&D) with the ADDIE model. It is a series of processes or steps to develop a new product or improve an existing product to be improved so that the results can be accounted for (Fayrus & Slamet, 2022). ADDIE is a development model with stages of analysis, design, development, implementation, and evaluation (Sugiyono, 2015). In this study, all stages of ADDIE were carried out effectively, starting from the analysis of needs, product design, development of the device, implementation, and evaluation. This research resulted in a product in the form of a biology learning device LMS based on socio-scientific issues (SSI) with environmental topics, which is expected to improve the argumentation and reflective judgment skills of grade X high school students.

Analysis is the initial stage of the research into the development of a biology learning LMS based on socio-scientific issues (SSI). This stage begins with a problem. Problems related to the environment always raise debates in the community. These environmental problems, in addition to raising social dilemmas, can of course be studied from a scientific perspective. In learning, the use of vapes and conventional cigarettes are examples of socio-scientific issues (SSI). Socio-scientific issues are dilemmatic or problematic issues that can be found in a society where scientific knowledge (biology) and social awareness are interrelated and present mental conflicts that require the ability to make decisions to solve them (Achwan et al., 2020). To make decisions, in addition to being based on scientific knowledge (biology), a person can also involve social humanistic perspectives such as moral-ethical, legal, or cultural considerations. Over the past decade, SSI has become one of the important themes of international science education research, although unfortunately this theme has not been widely developed in Indonesia (Achwan et al., 2020).

The development of the learning package in the LMS refers to the learning syntax based on SSI. SSI is a science topic whose subject is in a certain society so that it can deal with conflict situations concerning science and social life (Subiantoro et al., 2021). The topic raised in this learning package is river pollution due to the high use of baby diapers and sanitary napkins in the village of Situmbaga, South Angkola. Therefore, information is presented about the issue of the use of baby diapers and sanitary napkins in society. The learning package on this biology learning website is divided into three stages, namely the introduction (orientation), material (activities and material studies), and evaluation. The introductory stage consists of a description of the objectives and learning activities, orientation, and apperception. In this section, students begin learning activities by recognizing the problems or issues of the use of baby diapers and sanitary napkins in the social life of society and how they relate to the biology topic being studied.

The introduction is packaged in a video containing the opinions of the community, especially housewives, about the negative impacts of the use of baby diapers and sanitary napkins on the environment. Next, in the material stage, there are four learning activities that students go through. The first is Activity 1, where students hold a discussion to reflect on the phenomenon of the use of baby diapers and sanitary napkins and provide responses to the issue, with the guidance of the activity sheet provided. In the second part, namely Material Study 1, students listen to an explanation of environmental biology material through the video material presented. In the third activity, namely Activity 2, with the guidance of the activity sheet, students have a discussion accompanied by a literature study discussing the components in baby diapers and women's sanitary napkins that are difficult to decompose. The next

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stage is Material Study 2, where students study the types of material components that are composed of baby diapers and women's sanitary napkins so that they know their impact on the human environment.

Design is the second stage of designing a biology learning website based on SSI in this development research. The biology learning website based on SSI that was developed aims to accommodate student learning activities, especially on the human respiratory system material. This learning website presents various images, videos, and related data that are relevant to the material so that it is interesting and easy for students to understand. There are several discussion activities and delivery of discussion results and project creation that can encourage students to think critically, be active in discussions, express opinions, and make decisions. The development of this biology learning website based on SSI consists of collecting materials, designing a learning web framework, compiling a systematic sequence of material presentations, and compiling a learning web quality assessment instrument. From the analysis stage, web systematics was obtained that was adjusted to the SSI learning stages, with details presented in Table 2.

Table 2. LMS Systematic Stage

Learning Stages	Elements in LMS	Function
Orientation	Text, video, images	To draw students' attention to the issues raised
Activity 1	Digital student worksheets	To facilitate students to explore prior knowledge and opinions regarding the issues raised
Study Material 1	Digital material video	To provide a discussion material for essential biology material related to environmental systems
Activity 2	Digital student worksheets	To be inquiry-based activities to develop arguments and decisions
Study Material 2	Digital material video	To be a means of confirming biological science and decisions made based on these aspects
Evaluation	Aspect assessment	To measure students' knowledge, argumentation skills, and reflective judgment

The learning package on this biology learning website is divided into three stages, namely the introduction (orientation), material (activity and material study), and evaluation. The introductory stage consists of a description of the objectives and learning activities, orientation, and apperception. In this section, students begin learning activities by recognizing the problems or issues of using baby diapers and women's sanitary napkins in the social life of society and how they relate to the biology topic being studied. The introduction is packaged in a video containing the opinions of the community, especially housewives, about the impact of using baby diapers and women's sanitary napkins.

There are four learning activities that students undergo in the material section. The first is Activity 1, where students have a discussion to reflect on the phenomenon of the use of baby diapers and women's sanitary napkins and provide responses to the issue, with the guidance of the activity sheet provided. In the second part, namely Material Study 1, students listen to the explanation of the biology material on the topic of the environment through the video material presented. In the next activity, or the third activity, namely Activity 2, with the guidance of the activity sheet, students have a discussion accompanied by a literature study discussing the materials in baby diapers and women's sanitary napkins. Next is Material Study 2, where students can learn about the materials in baby diapers and women's sanitary napkins and their impact on the human environment.

In the evaluation stage, students evaluate learning outcomes in the form of reflection and knowledge tests of understanding of biology material, each through the menu provided. In the reflection section, after students have previously carried out literature review and discussion activities and studied the material presented, they are invited to reflect on the issue of using baby diapers and women's sanitary napkins and their relationship to the environment.

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Product Quality

Development, the third stage of designing a biology learning website based on SSI in development research is divided into three stages, namely writing/compiling a draft of the biology learning device LMS model, editing I, and revision I of the initial learning web product, and editing II and revision II of the learning web product. Writing a draft of the learning device LMS model is the process of compiling components of the learning LMS which are constructed through several references. Having been approved by the supervising lecturer, the draft entered the editing and revision stage I. Editing stage I was the stage where the learning web product got a review or validation from the material expert and learning media expert.

The assessment of the developed LMS of SSI-based biology learning devices to improve the argumentation and reflective judgment skills of high school students was carried out by four validators. The assessment was carried out by reviewing the aspects of biology study information, learning organization aspects, web/LMS operational presentation aspects, and biology study language aspects. The validators' assessment of the LMS learning device reviewed from the biology study information aspect is observed in Table 3 below.

Table 3. Information Aspects of Biological Studies

Numb.	Aspect Components	Validator Assessment		PRS	Interpretation	Category
		Validator 1	Validator 2			
1	Completeness of Components in LMS	4	4	80	High	Valid
2	The truth of material/content	4	4	80	High	Valid
3	Conformity with the applicable curriculum	4	3	70	Moderate	Valid
4	Conformity with the socio-scientific issues (SSI) approach	4	4	80	High	Valid
5	Stimulation of students' argumentation and reflective judgment skills	4	3	70	Moderate	Valid
6	Suitability of the time allocation used	5	4	90	High	Valid
7	Conformity of material sequence	4	5	90	High	Valid
Average value		4.14	3.85	80	High	Valid

Table 3 shows the results of the validator's assessment of the biology LMS learning device, which obtained an average score of 80, which is in a valid category. It can be concluded that the information aspect of the biology study in the device is very suitable for use as a learning medium. This reflects that the material presented in the LMS has met the content validity criteria, which follows the latest theory on the importance of measuring instruments that are relevant to learning objectives, as expressed by Yang, Y (2023), which emphasizes the importance of content conformity with applicable curriculum standards. In addition, the validator's suggestion that the implemented curriculum follow the applicable curriculum and that teaching materials be arranged logically and in an integrated manner is very relevant to the principles of organizing materials put forward by Ahmad Dhomiri et al (2023), which emphasizes the importance of clear structure in instructional design.

Another suggested input is to simplify the reading material so that it is easy for students to understand, following the opinion of Jacobs & Usher, (2018) about the zone of proximal development (ZPD), which shows the importance of adjusting the material to the student's level of understanding. The revision based on this input shows a continuous effort to improve the quality of learning tools, and this improvement step is important to increase the effectiveness of learning and ensure that the biology LMS can be used optimally to support more effective and comprehensive learning. The results of the assessment on the aspect of learning organization are presented in Table 4.

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Table 4. Aspects of Learning Organization

Numb.	Aspect Components	Validator Research		PRS	Interpretation	Category
		Validator 1	Validator 2			
1	Clarity of material division in learning devices	4	4	80	High	Valid
2	Clarity of SSI learning steps	3	4	70	Moderate	Valid
3	Clarity of instructions on the LMS menu	4	5	90	High	Valid
4	Clarity of instructions in student worksheets	4	5	90	High	Valid
5	Clarity of instructions on evaluation	4	4	80	High	Valid
Average value		3.8	4.4	82	High	Valid

Table 4 depicts the assessment of the two validators on the five components in the learning organization aspect. It shows the biology LMS device obtained an average score of 82, which is in a high and valid interpretation category, indicating that this device is very suitable for use as a learning medium. This assessment reflects that the material in the LMS has been arranged systematically and coherently, following the principles of instructional design that emphasize logical sequence and clarity in each step of learning (Khalil & Elkhider, 2016). However, the validator provided input regarding the clarity of the learning steps in the socio-scientific issue (SSI) approach, where it was suggested that the SSI syntax be placed in a special menu in the LMS. This aims to make it easier for students to understand the steps that must be taken in learning while reducing confusion.

Revisions based on validator input are very important to improve the quality of learning tools (Omran et al., 2015). By placing the SSI syntax in a dedicated menu, learners will have easier access to important information related to learning steps, which in turn will improve their understanding of the material being taught. This revision will support the effectiveness of the LMS in providing a more optimal learning experience, following the principles of clear and structured instructional design (Ghazal et al., 2018). Thus, the revised biology LMS will be more effective in achieving learning objectives and can be continued to the next stage of development. The results of the assessment on the operational presentation aspect of LMS learning are in Table 5.

Table 5. Operational Presentation Aspects of LMS

Number	Aspect Components	Validator Review		PRS	Interpretation	Category
		Validator 1	Validator 2			
1	Clarity of learning device menu division on LMS	4	4	80	High	Valid
2	Creativity and innovation in developing LMS-based biology learning tools	4	5	90	High	Valid
3	Ease of use of LMS	5	4	90	High	Valid
4	Learning device layout/space settings including display color, font type, and button placement on the LMS	5	3	80	High	Valid
5	Maintainability (Can be managed easily)	4	3	70	Moderate	Valid
Average value		4.4	3.8	82	High	Valid

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Based on Table 5, the assessment of the two validators on the five components in the operational presentation aspect of the LMS shows that the biology learning device obtained an average score of 82, which is in a high and valid interpretation category. This shows that the biology LMS device has a clear and effective structure in presenting information and can be used well by students. Good operational presentation is very important to support successful learning and organized and easy-to-understand material can improve the learning experience (Roksa et al., 2017). In addition, according to Bolkan et al (2017), learning tools that have clear and easily accessible instructions will help students follow learning more effectively. The high scores obtained indicate that the operational aspects of the LMS have met the standards required to support effective biology learning.

However, although the operational aspects obtained a good score, the validator provided input related to the clarity component of the learning steps in the socio-scientific issue (SSI) approach. The suggestion given is to place the SSI syntax on a special menu in the LMS so that students can easily understand the steps that must be taken in learning. This is important because, as explained by Kinslow et al (2019), the SSI approach requires a deep understanding and active involvement of students in solving science problems related to social and environmental issues. Placing the SSI syntax in a special menu will help students access important information more easily, which in turn improves their understanding of the material. Revisions based on these inputs are essential to ensure that the biology LMS can be used optimally and be more feasible to proceed to the next stage in learning development. The results of the assessment of the biological language learning aspect are presented in Table 6.

Table 6. Aspects of Biological Language Studies

Numb.	Aspect Components	Validator Review		PRS	Interpretation	Category
		Validator 1	Validator 2			
1	The language used in the media is easy to understand	4	3	90	High	Valid
2	The language of the material in this learning media makes it easier for students to understand the material.	5	4	90	High	Valid
3	The instruction language on the LMS menu is attractive.	4	5	90	High	Valid
4	The instruction language in student worksheets is easy to understand.	4	4	80	High	Valid
5	The language of the material presented is easy to analyze.	4	5	70	Moderate	Valid
Average value		4.2	4.2	84	High	Valid

Table 5 depicts the assessment of the two validators on the five components in the biology language study aspect. It shows the biology LMS learning device obtained an average score of 84, which is in a high and valid interpretation category. This score reflects that the language used in the device is appropriate to support biology learning, with explanations that are quite clear and easy for students to understand. The use of appropriate language is very important in learning, especially in science-related materials, where complex concepts need to be conveyed simply and easily digested by students (Mönch & Markic, 2022). The use of simple and clear language in learning instructions can improve students' understanding and retention of information (Grammer et al., 2013). With this high score, the biology LMS device can be considered very worthy to be used as a learning medium, because it has met the criteria of clarity and language acceptability that suit students' needs.

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However, the validator provided some important input, one of which was to simplify the language of the material in the questions so that students could digest the information more easily. This suggestion is in line with the principles of instructional design expressed byLewis (2016), which emphasizes that reducing cognitive load is essential to improving student understanding, especially in the context of material that requires high-level thinking. In addition, the validator also suggested placing the SSI syntax on a special menu in the LMS so that students could understand the steps to be taken in learning more easily. This is very relevant because the SSI approach used in this tool requires a clear structure so that students can effectively link science issues to social and environmental contexts (Hernández-Ramos et al., 2021). Revisions based on this input will ensure that the SSI-based Biology LMS can be more effective in supporting learning that focuses on solving science problems that are relevant to student's daily lives, following the applied curriculum. This LMS product has successfully gone through two revisions based on input from media experts, material experts, and biologists, and is now ready for wider use in biology learning.

The LMS product of SSI-based biology learning devices has passed the validation process and has been declared successful. It has been revised twice based on input from media, material, and biology experts. The details of the material contained in the LMS include environmental balance and change, environmental pollution, accumulation of pollutants in the food chain, waste management, community dynamics, and adaptation and mitigation of the environment. The LMS product of SSI-based biology learning devices was developed based on the website accessed at https://lmsssismaangsel.edukati.com. The topic in the SSI-based biology learning device LMS is the environment which is structured based on the Merdeka Curriculum through TP, ATP, teaching modules, and teaching books.

Implementation

Limited trial

The results of the revision of the SSI-based biology learning device LMS based on input from media experts, material experts, and biology teachers were then tested limitedly. This test aimed to obtain students' readability responses to the developed product. The small training subjects consisted of 17 students X 2 at the school. Students were allowed to access and study all the contents of the material contained in the LMS. Furthermore, students filled out a product readability questionnaire distributed online via Google Forms. Students could also write input through the questionnaire as material for improving the LMS. The results of student responses to the LMS are shown in Table 7.

Table 7. Student Readability Test Results

Numb.	Aspect Components	Total Score	Mean	Category
1	Clarity of learning device menu division on LMS	65	86.6	High
2	Clarity of material division in learning devices	64	85.3	High
3	The language of the material in this learning media makes it easier for students to understand the material.	63	84	High
	Average value	64	85.3	High

Based on Table 7, the results of students' assessments of the SSI LMS-based Biology learning device indicate that the device is feasible to use, with an average value of 85.3, which is in a high category. This score indicates that the device meets the expected quality criteria in supporting biology learning, especially in the context of developing students' argumentative and reflective skills. Effective learning devices must be able to activate students' cognitive processes, improve their understanding of the material, and enable them to apply knowledge in relevant contexts (Anguera & Gazzaley, 2015). With positive assessment results from students, this tool has demonstrated its ability to achieve learning objectives and is ready to proceed to the field testing stage, which is an important step in ensuring the successful implementation of this tool in a broader context.

The field trial aims to determine the effectiveness of using LMS as a biology learning tool to improve students' argumentative and reflective judgment skills. The effectiveness of the product can be seen based on the results obtained by students' pretest and posttest gain scores. Students' argumentative abilities are measured by giving written pretests and posttests of questions based on issues presented to

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the control and experimental classes. The contents of the written test questions contain indicators of students' argumentative abilities consisting of claim, data, warrant, backing, and qualifier. The measurement results are shown in Table 8.

Table 8. Results of Measurement of Students' Argumentation Ability

Class	Assessment Results		N-gain	Category
	Pretest	Posttest		
Control	65, 74	69.77	0.12	Low
Experimental	71.77	85.00	0.47	Moderate

The results of the analysis in Table 8 show that the argumentation ability of students in the experimental class using SSI-based LMS learning devices experienced a significant increase, with a gain score (g) of 0.47, which is included in the moderate category, while the control class using textbooks, videos, and PowerPoint only obtained a gain score of 0.12, which is classified as low. This difference shows that SSI-based LMS devices are more effective in improving students' argumentative abilities compared to traditional learning methods. This is in line with educational theory which explains that the use of digital media allows students to be more involved in discussions and collaborations, which supports the improvement of their cognitive and argumentative skills (Gan et al., 2015). The SSI-based approach in LMS allows students to explore social and scientific issues relevant to their lives, which strengthens critical thinking skills and builds stronger arguments (Martini et al., 2021). In addition, learning contexts that connect science concepts with social issues motivate students to put forward more informed and meaningful arguments (Anwar & Ali, 2020). Compared to traditional learning which tends to be passive, the use of SSI-based technology and methods encourages students to think more deeply, which in turn improves the quality of their arguments (Setyaningsih et al., 2019). Recent research also supports this finding, showing that LMS-based technology combined with the SSI approach can significantly improve students' argumentation skills (Arsyad, 2023).

Reflective judgment ability was measured using pretest and posttest questionnaires in the control and experimental classes. The questionnaire content includes the level of reflective judgment ability, namely the pre-reflective category, which is limited by one concrete truth. The second category is quasi-reflective, which consists of two levels, limited by uncertainty in the belief system. The last category is the reflective category, covering levels 6-7, characterized by individuals who have shifted from being information recipients (passive) to information makers (active). Data on the increase in reflective judgment ability are shown in Table 9.

Table 9. Results of Reflective Judgment Ability Measurement

Class	Assessment Results		N-gain	Category
	Pretest	Posttest		
Control	73.72	80.12	0.24	Low
Experimental	74.31	87.24	0.50	Moderate

Table 9 shows an increase in the average reflective judgment value in both groups - control and experimental classes -, which reflects the development of students' reflective thinking skills. Reflective judgment refers to the ability to evaluate information, consider multiple perspectives, and develop decisions based on critical analysis (King & Kitchener, 2004). This increase in value indicates that the learning process involving active reflection, as applied in the experimental class, can facilitate the development of students' critical thinking skills. Based on the results of the gain score analysis (<g>), the difference between the control and experimental classes became clear, with the experimental class gaining a higher score increase (0.50) compared to the control class (0.24). This indicates that a technology-based approach, in this case, the LMS learning device that uses SSI (socio-scientific issues), can have a more significant impact on students' reflective judgment skills.

The use of LMS-based learning media that integrates SSI provides students with a deeper experience to analyze science problems that are contextual and relevant to social issues. Social science issue-based learning encourages students to think critically and reflectively about topics related to their daily lives (Kitchener & King, 1981). On the other hand, the control class using video-assisted textbooks

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and PowerPoint may not provide similar levels of engagement and reflection, as these methods tend to be more passive in engaging students in in-depth discussions and analysis. Therefore, this difference in learning media suggests that LMS-based learning technology that integrates SSI is more effective in improving students' reflective judgment skills, as it allows them to be more active in critical thinking, analyzing, and concluding information by considering multiple perspectives.

The results of the data analysis show that the development of LMS for biology learning devices can train students to be skillful at arguing. LMS for biology can present information in a complex, interactive, and fun way. Students who are skillful at arguing can make claims of information, data/facts, guarantees, support, and reinforcement of the issues presented. Learning to argue is an important way of thinking that facilitates conceptual change and is important for problem-solving, supporting deep engagement with ideas (Jonassen & Kim, 2010). A learning management system (LMS) can support trainers in the development and implementation of argumentative learning designs, which effectively improve argumentative skills (Lestari et al., 2021).

The development of LMS learning tools is one solution to overcome environmental problems, especially those related to river pollution in the village. In this context, the more comprehensive the students' knowledge, the more sensitive they will be to the surrounding environment. Efforts to prevent river pollution can be made by providing education to the community about the existence and benefits of the river (Noorhosseini et al., 2017). Community empowerment activities in maintaining river cleanliness, such as cleaning, effectively reducing river pollution, and making rivers useful for local communities (Angriani et al., 2018). In addition, environmental education develops and enhances environmental attitudes, values, knowledge, and skills, preparing individuals and communities to collaboratively undertake positive environmental actions (Ardoin et al., 2020).

Gain score and effect size analysis on reflective judgment variables show that the level of influence is in the moderate category. SSI-based biology learning LMS provides an increase in students' reflective judgment abilities. In other relevant studies, it is explained that socio-science issues learning significantly improves the development of students' reflective judgment by fostering sophisticated epistemological attitudes and evidence-based reasoning (Dwyer et al., 2015). The biology learning device LMS product is disseminated by distributing the website address to biology teachers and students. Teachers can use the website in the teaching process directly or online. The SSI-based biology learning device LMS product can also be used to improve science learning objectives more broadly.

CONCLUSION

Based on the research conducted, it can be concluded that the developed learning management system (LMS) for biology instruction meets the feasibility criteria, with an average score of 82% based on assessments from material experts. The assessment covers various aspects, including biological study information (80%), learning organization (82%), LMS operational presentation (82%), and language usage (84%). Following its validation, a limited trial was conducted with students, yielding a score of 85.3%, indicating that the developed media is highly feasible for implementation in high school biology education. Additionally, the field test results demonstrate that the use of LMS as a biology learning tool effectively enhances students' reasoning and reflective judgment skills. The results show that the experimental class outperformed the control class in both argumentation and reflective judgment, with scores of 0.47 (medium category) for argumentation and 0.50 (medium category) for reflective judgment. Therefore, it can be conclusively stated that the SSI-based biology learning LMS is effective in improving students' reasoning and reflective judgment abilities.

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