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Needs Analysis for the Development of E-Modules Argument Driven Inquiry Contextualized Socio Scientific Issues to Empower Students' Scientific Argumentation Skills

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A B S T R A C T

This study aims to analyze the need for developing E-modules Argument Driven Inquiry (ADI) with Socio Scientific Issues (SSI) context on environmental change material to empower students' scientific argumentation skills. The research method used is descriptive qualitative method with data collection techniques through interviews and questionnaires. The subjects of this study were biology teachers and 60 students of SMA Negeri 4 Surakarta. The results of the needs analysis showed that teachers and students need technology-integrated teaching materials in the form of ADI E-modules with SSI context on environmental change material. The development of ADI E-modules with SSI context is expected to be an alternative learning solution that is innovative and effective in improving the quality of biology learning which has implications for empowering students' scientific argumentation skills.

1. Introduction

The era of globalization and the rapid development of science and technology (IPTEK) requires individuals to have a set of essential 21st century skills (Larson & Miller, 2011). Some of the 21st century skills that students must master are the 4C skills, namely critical thinking, creative thinking, collaboration and communication. In the 21st century, education places significant emphasis on developing communication skills, one of which is scientific argumentation as an essential skill. Teaching this skill requires instructional design that allows students

to actively construct and criticize arguments, support claims with evidence and reasoning, and then reject opposing claims and evidence (Hendratmoko et al., 2024).

One of the skills that students must have in 21st century science learning is scientific argumentation skills (Fan et al., 2020). Scientific argumentation skills are associated with strong concept understanding and improved critical thinking and scientific literacy (Sahil et al., 2022). Scientific argumentation is basically difficult to separate from science because argumentation is a structural element in the language of science, which is a strategy for resolving questions, problems and disputes. Argumentation in science learning, especially biology, has a big role in building students' knowledge based on scientific beliefs and reasons. Biology learning basically requires students to think critically in finding concepts or solving problems (Lee et al., 2021). The scientific problem solving process is a thinking process that requires a foundation of critical and logical thinking through good argumentation skills, because students' arguments must be equipped with supporting scientific data and evidence (Wang et al., 2021).

Scientific argumentation skills are closely related to crucial issues in facing increasingly complex global challenges, including environmental issues studied in biology learning (Tang et al., 2024). Environmental change is one of the crucial issues in biology that requires deep understanding and strong scientific argumentation skills from the younger generation (Aziz & Johari, 2023). Scientific argumentation is an important skill in science that enables students to construct, evaluate, and communicate claims based on evidence and reasoning (Erduran et al., 2004). Scientific argumentation involves several components, including claims, evidence, assurance, support, refutation, and qualification (Toulmin, 2003). This skill is not only important in a scientific context, but also in everyday life when one is confronted with a variety of information, especially regarding social issues, and needs to make evidence-based decisions (Jimenez et al., 2024).

The Programme for International Students Assessment (PISA) survey organized by the Organization for Economic Cooperation and Development (OECD) in 2022 in order to measure the level of science literacy of 15-year-old students showed that Indonesia occupied a low position, namely the bottom 15 out of 81 countries participating in the survey with a score of 383. The science literacy score of Indonesian students decreased by 13 points compared to the results of the previous PISA survey. On the other hand, based on the ability level, the percentage of Indonesian students who entered the ability level 2 in the field of science literacy is 34.16% which is still far from the average of other OECD countries which is 75, 51%. The low level of science literacy indicates that students' skills in voicing arguments during the learning process are less empowered (Sukarso et al., 2023). In fact, science literacy is an important part of argumentation skills and by mastering science literacy skills, students can easily provide evidence and justification in depth to strengthen the arguments put forward (Rosyidah et al., 2023).

The problem of low scientific argumentation skills is also interpreted by various findings from previous studies which conclude that students' scientific argumentation skills in secondary schools still need to be improved. The problems found are that students often have difficulty in providing relevant evidence, linking evidence to claims, and considering alternative perspectives (Sengul, 2019). In addition, low scientific argumentation skills are suspected to be caused by various factors, including lack of experience in argumentation, lack of understanding of argumentative approaches and lack of teaching materials that support the development of scientific argumentation skills (Ping et al., 2020). Teaching materials are a learning support system that has a central role in achieving certain learning objectives, so efforts to develop innovative and effective teaching materials are very important.

The development of teaching materials must be equipped with an approach that is relevant to the learning context. One alternative approach that can support argumentation activities is Argument Driven Inquiry (ADI). ADI is a structured learning approach to develop students' argumentation skills through scientific inquiry and debate activities (Sampson et al., 2010). In ADI, students not only learn about scientific concepts, but also learn how to think and work like scientists (Kuki et al., 2023). ADI involves several stages, including identification of research questions, data collection, data analysis, argument development, argument evaluation, and argument revision. Through these stages, students learn to formulate relevant research questions, collect and analyze data systematically, construct arguments based on evidence, evaluate others' arguments, and revise their own arguments based on evidence and reasoning (Arslan et al., 2023).

The implementation of the ADI approach is very relevant to social scientific issues known as Socio Scientific Issues (SSI). By examining crucial social scientific issues through ADI activities, students can find their understanding independently and can conduct scientific debates and dialectics so as to improve important skills such as scientific argumentation (Dianti et al., 2023). To help facilitate the provision of argumentation activities, teaching materials are needed that can support the application of empowering argumentation skills in learning. One of the teaching materials that has proven effective in accommodating argumentation activities is E-modules.

E-modules as digital teaching materials can provide applicative space to accommodate argumentation activities provided in the ADI approach. In addition, E-modules can be an exploration space that helps students to independently discover scientific concepts related to environmental change material, especially social scientific issues in the environment that need to be debated and solutions sought (Sukarso et al., 2023). So the purpose of the research is to analyze the need for developing ADI E-modules with SSI context on environmental change material to empower students' scientific argumentation skills. With this analysis, it can be a substantive consideration for developing E-modules which hopefully can become innovative and effective teaching materials in improving the quality of biology learning and empowering students' scientific argumentation skills.

2. Methodology

The type of research used is (R & D) or research and development (Sugiyono, 2019). The development stages used in this study are the ADDIE development model developed by (Branch, 2009) with development steps consisting of 5 stages, namely; Analysis, Design, Development, Implementation and Evaluation. The ADDIE development model scheme is presented in Figure 1.

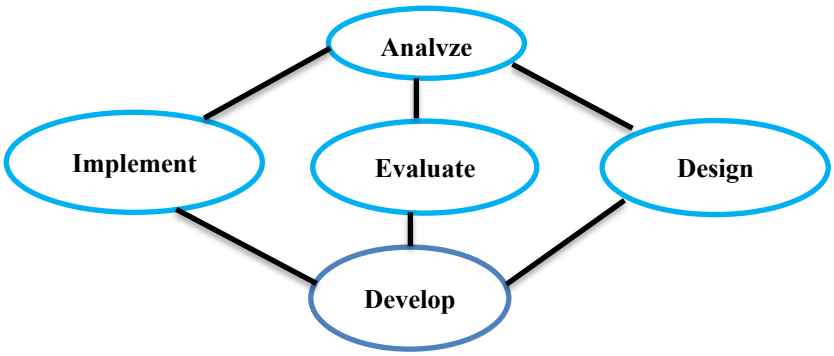

Figure 1. Schematic of the ADDIE Model (Branch, 2009)

This research will develop an ADI E-module product with SSI context with the aim of training scientific argumentation skills. This research was conducted at SMA Negeri 4 Surakarta. The sampling technique used purposive sampling technique (Cohen et al., 2007). This research is the initial stage of the ADDIE model, namely analyze the needs of E-module development. The instruments used were structured interview sheets and validated needs analysis questionnaires. Research data were collected through structured interviews with biology teachers as a teacher needs analysis. In addition, 60 students class X were selected to fill out the research questionnaire through google form to analyze student needs. This selection was based on the criteria of students' academic and communication abilities based on the teacher's assessment. The research procedure for this needs analysis can be summarized in Figure 2.

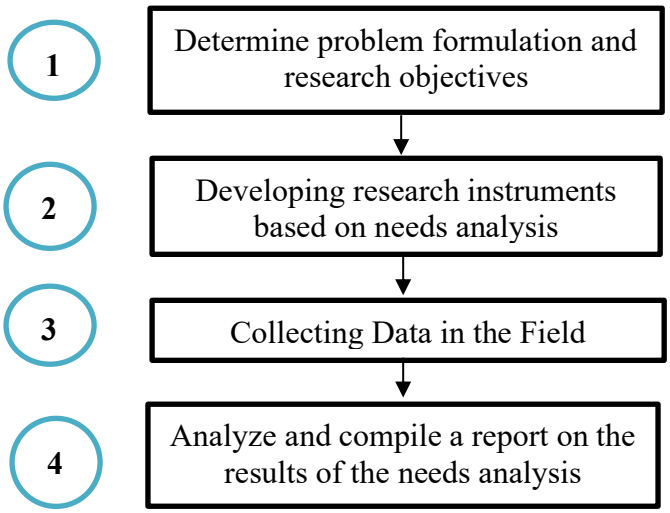

Figure 2. Research Procedure

3. Result and Discussion

The results of this study present data in the form of teacher needs analysis and student needs analysis which are used as initial supporting data in the development of E-module products. This needs analysis instrument was developed based on biology learning indicators and research variables which resulted in 20 exploratory questions for teachers and 10 substance statements for students.

Data Analysis of the Needs of Biology teachers

Based on the results of interviews with biology teachers, teacher needs analysis data were obtained which can be described in table 1.

Table 1. Results of Teacher Needs Analysis

No	Question	Teacher Response
1	What kinds of student skills taught in biology learning do you know?	In the implementation of learning so far, I have tried to teach various skills such as critical thinking skills, communication, science literacy, collaboration and science processes.
2	Have you ever heard of scientific argumentation skills?	I have heard but not really understood the difference between ordinary argumentation and scientific argumentation.
3	How important do you think scientific argumentation skills are in the curriculum?	I think scientific argumentation skills are very important for the implementation of learning, especially in materials that require discussion and argumentation activities.
4	How do you think you can train students' scientific argumentation skills?	In my opinion, to train scientific argumentation skills, students must be given a problem to analyze.
5	Do you agree that the purpose of learning biology is for students to discover knowledge through investigation and argumentation?	Yes, I agree because one of the learning objectives of biology is that students can discover concepts independently with various relevant approaches.
6	Is environmental change material a complicated material to teach in biology learning?	In my opinion, environmental change material is material that is not so complicated but it is also not easy to teach environmental change material so that a special approach is needed.
7	Have you trained students' scientific argumentation skills in learning about environmental changes?	I have never specifically trained scientific argumentation skills in biology learning, especially on environmental change material.
8	Do you often use learning media to teach environmental change material?	Yes, I often use learning media in biology learning activities, especially on environmental change material to help students learn.
9	What learning media do you most often use to teach environmental change material?	In the implementation of learning so far, I have used various learning media such as PPT, YouTube videos, textbooks and modules.
10	Can the media you use	I think that with the existing media, students'

	empower students' scientific argumentation skills?	scientific argumentation skills have been trained, but only a few students are active to convey in argumentation activities.
11	Do you need an interactive E-module that can help in supporting the learning of environmental change material?	Yes, I really need interactive learning media so that students can utilize it in learning.
12	Have you applied the learning model on environmental change material?	Yes, I have implemented a learning model but the model used has not been very varied.
13	What learning models do you often use in learning about environmental change?	In the implementation of learning on environmental change material, so far I have used the problem-based learning model.
14	Has the learning model that you use empowered students' scientific argumentation skills?	In my opinion, the PBL model has empowered scientific argumentation skills but has not been so effective in making all students active in argumentation.
15	Have you ever implemented learning using the ADI model with the context of SSI in learning about environmental change?	I have just heard about this learning model, so in the implementation of learning I have never applied it.
16	How much time allocation for biology lessons do you use for environmental change material?	So far, the time allocation for biology lessons, especially on environmental change material, is 8 lesson hours.
17	What forms of assessment do you often use in evaluating the learning implementation of environmental change materials?	I usually use multiple-choice questions and descriptions as well as descriptions with open-ended questions.
18	Have you ever made assessment questions that are directed at empowering scientific argumentation skills?	I have never created assessment questions that are specifically geared towards empowering scientific argumentation skills.
19	Is the school facilitated by good learning technology and internet network to support learning?	Yes, our school has provided facilities such as the internet and other learning technologies that support learning.
20	Do your students have smart phones that make it easy to access learning media?	Yes, all students in our school have smart phones.

Data Analysis of Student Needs

Based on the results of filling out the questionnaire, student needs analysis data were obtained which can be explained and described in Table 2.

Table 2. Results of Student Needs Analysis

No	Statement	Response Option (%)	
		Yes	**No**
1	Biology learning is student-centered.	96,7	3,3
2	Teachers use various methods in learning biology.	100	0
3	In my opinion, biology subject matter is very easy to understand and comprehend.	60	40

4	The teaching materials used by the teacher so far can help me understand the biology subject matter easily.	71,7	28,3
5	I conduct scientific debates and discussions in biology lessons.	66,7	33,3
6	In my opinion, scientific argumentation is very important in learning biology.	90	10
7	I have used various teaching materials in biology learning activities so far.	100	0
8	I need other teaching materials in learning biology such as electronic modules (E-Modules) that are presented digitally interactive and the material is linked to scientific social issues.	96,7	3,3
9	I have used electronic modules (E-modules) in learning biology.	90	10
10	I agree that the development of teaching materials such as electronic modules can make biology learning more innovative so that it helps me understand biology subject matter.	98,3	1,7

Discussion

The results of the needs analysis of biology teachers and students at SMA Negeri 4 Surakarta provide an in-depth understanding of the dynamics of biology learning in this school. In this analysis, there are two complementary perspectives, namely the views of biology teachers and responses from 60 students. The combination of these two perspectives shows the potential and challenges that exist in the implementation of biology learning, especially in the development of scientific argumentation skills.

The results of the analysis on students showed that 96,7% of students stated that learning was student-centered. This illustrates that the biology learning carried out has implemented independent curriculum-based learning. According to Maulidia et al. (2023) the implementation of an independent curriculum requires student-centered learning, therefore the learning process is expected to use a scientific approach that can facilitate students in strengthening attitudes, skills and knowledge to produce productive, effective, innovative and creative students. Through the scientific approach, the learning process becomes more optimal and effective compared to traditional learning.

The results of the analysis on students are supported by the views of teachers who stated that in the implementation of biology learning, teachers have attempted to teach various skills, including critical thinking, communication, science literacy, collaboration, and the science process which shows that teachers have provided a student-centered active learning space. However, when asked about scientific argumentation skills, teachers stated that they knew about scientific argumentation skills but did not fully understand the difference between ordinary argumentation and scientific argumentation. This view suggests that although teachers have an awareness of the importance of scientific argumentation skills, there is still room for further improvement in understanding and training. According to Dewantari et al. (2022) argumentation skills need to be further improved in biology learning, especially in materials that are relevant to argumentation-based learning mechanisms.

The teacher also emphasized that scientific argumentation skills are very important in the context of biology learning, especially in materials that involve discussions and various scientific opinions. With the need to understand different points of view, argumentation skills are key for students to discover knowledge. On the other hand, students also consider scientific argumentation activities important in biology learning, with 90% of students stating that scientific argumentation skills are very important. This illustrates the similarity of perspectives between teachers and students regarding the importance of argumentation in the learning process.

The importance of scientific argumentation skills is also stated by Suraya et al. (2019) & Hasmaningsih et al. (2022) who stated that scientific argumentation skills need to be fully empowered in learning because it can help students improve their communication skills and scientific thinking. Meanwhile, to train scientific argumentation skills, teachers argue that students need to be given problems to analyze. This method is considered effective because it can involve students actively in the learning process. The results of the analysis show that 66,7% of students have been involved in scientific debates and discussions, although there are still 33,3% of students who feel they have never done so. This suggests that there are still students who need to be encouraged to participate more actively in biology learning.

Regarding learning materials, teachers consider that environmental change materials are not too complicated but require a special approach to be taught. In addition, teachers also recognize the importance of using learning media as a tool to support students' understanding. Teachers often utilize various media such as PowerPoint, YouTube videos, textbooks, and modules in learning. Interestingly, 100% of students also said that they use various teaching materials in biology learning, indicating that they are open to diverse learning resources. According to Diartika et al. (2024) the use of appropriate learning resources will assist students in understanding environmental change material as well as being positively oriented towards improving other important skills. This view is also in line with Dalaila et al. (2022) who revealed that quality learning resources will have a direct impact on increasing student interest and learning outcomes.

The learning media used by the teacher is considered to have had a positive impact on students' argumentation skills. However, teachers noted that there were only a few students who were active in presenting arguments in learning activities. Teachers agree that the development of interactive E-modules is one of the alternative teaching materials so that students can access more interesting and informative learning media. Specifically, 96,7% of students also feel the same way and want interactive teaching materials that can stimulate more innovative and contextualized biology learning. This is in line with Susilawati et al. (2023) who stated that E-modules can be one of the innovative teaching materials in providing innovative and varied learning approaches so that it can help students in learning activities.

In terms of learning models, teachers have implemented the problem-based learning (PBL) model. Although PBL has been considered to empower scientific argumentation skills, teachers feel that many students are still not active in argumentation. The results of the analysis show that teachers feel the need to explore other learning models, which can increase student participation in argumentative activities. Previous research shows that the use of active learning models can improve students' critical thinking and communication skills (Rahayu et al., 2020). In addition, the results of the analysis show that teachers have never implemented ADI-based learning with the context of SSI. This shows the importance of applying the ADI approach with the SSI context as an alternative to the new learning approach so that it can be used as an innovation in biology learning. According to Dianti et al. (2023) the application of the ADI approach with SSI context is an important innovation in biology learning, especially to explore students' argumentation skills in the context of crucial social scientific issues.

The importance of time allocation in learning is also highlighted in this analysis, it was found that teachers allocate 8 lesson hours for learning biology, especially on environmental change material. This allows students to have sufficient opportunities to explore the material and develop other important skills. In addition, the form of assessment used by teachers, mostly in the form of multiple choice questions and descriptions that do not include an assessment of scientific argumentation skills specifically. This has prompted the need to prepare an evaluation system that measures scientific argumentation skills specifically. According to Suwono et al. (2017) the form of assessment directed at measuring argumentation needs to be carried out by teachers because it has positive implications for argumentation-oriented learning.

Access to learning technology in schools is in good condition. Teachers and students have adequate access to information technology and the internet, which are important drivers of modern learning. This is important given that technology can be a mediator that strengthens teaching and learning interactions. Previous research also notes that technology accessibility contributes to learning success in more innovative models (Surya & Moramowati, 2023). The availability of technology and network access is also supported by the presence of smart phones among students, where 100% of students already own the devices. This opens up vast opportunities to utilize various applications and digital media in the learning process, including access to interactive E-modules. The reliance on digital platforms also marks a shift in learning in the contemporary era, where students are more adaptive in using technology as a learning resource and medium.

Through this needs analysis, it is clear that both teachers and students at SMA Negeri 4 Surakarta recognize the importance of scientific argumentation skills. Although there are challenges in implementing existing learning practices, there is a strong desire to further develop methods, strategies, and teaching materials in biology education. This study illustrates the hope for creating more innovative, interactive learning that meets the needs of students within the dynamic context of biology education. Therefore, the development of an ADI E-module

contextualized with SSI on environmental change material to train students' scientific argumentation skills becomes a necessity. This includes the development of the E-module and efforts to explore more varied learning approaches, with a focus on empowering and engaging students in presenting their arguments and opinions on scientific issues. This will make biology learning not just a transfer of knowledge but also a meaningful and contextual learning experience.

4. Conclusion

Based on the results of the needs analysis that has been carried out on teachers and students, it is concluded that it is necessary to develop an ADI E-module with an SSI context on environmental change material to empower students' scientific argumentation skills. This is indicated by the expectations of teachers who require technology-integrated teaching materials such as E-modules. In addition, teachers have never implemented learning with an ADI approach with an SSI context on environmental change material. While on the other hand, almost all students stated that they needed teaching materials such as E-modules that provide independent, exploratory, and interactive learning spaces in biology learning activities. The development of this E-module is expected to provide a different approach to biology learning, namely an argumentation-based investigation approach that is able to visualize and present interesting material related to current environmental social scientific issues so that it can create innovative and meaningful biology learning whose implications empower student scientific argumentation skills.

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