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Cultivating Scientific Literacy: Developing A Biodiversity E-Module Based on Socioscientific Issues and Local Potential

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ABSTRACT

The existing literacy program in the higher education has not successfully translated into effective science learning, resulting in students lacking awareness of the significance of scientific literacy in their daily lives. This study aims to analyse the validity, practicality and effectiveness of using biodiversity e-module based on socioscientific issues and local potential to improve students' scientific literacy. The method employed in this research is the research and development (R&D) method using the ADDIE model. The participants of this study are 37 fourth-semester students enrolled in the Tadris IPA Program at UIN Fatmawati Sukarno Bengkulu, who are taking the biodiversity course in the academic year 2023/2024, consisting of one class. Data collection was conducted through an indirect communication approach using instruments such as validation questionnaires and tests to obtain data on scientific literacy achievements. The findings of this study are the utilization of biodiversity teaching materials grounded in socio-scientific issues and local potential is highly suitable for implementation in science education. The instructional materials exhibit a commendable feasibility level, meeting the criteria for good feasibility. This indicates that the teaching materials are readily comprehensible for students. Moreover, the developed teaching materials prove effective in enhancing four key facets of scientific literacy such as the body of knowledge, science as a way of investigation, science as a way of thinking and the interaction of science and technology and society.

Keywords: **E-Module, Biodiversity, Local Potentials, Socio-Scientific Issues, Scientific Literacy.**

A. INTRODUCTION

One of the important achievements in science education in the 21st century is science literacy. To analyze, synthesize and evaluate data, science literacy is essential for decision-making. As information is always changing, students must have the ability to manage and respond to problems. The goal of science literacy is to prepare students to think in a rapidly evolving world of science and technology (Hurd, 1998; National Academies of Sciences and Medicine, 2016). Students who have science literacy have benefits in life after school because they have the experience to analyze problems used in learning (Lederman et al., 2013). In the early 21st century, science education focuses on students' ability to understand and comprehend science before they leave school.

Currently, the main goal of science learning is science literacy. Therefore, science literacy is very important for students to master as the younger generation as it prepares them to become science literate citizens who can make decisions and participate in solving social problems in society (Valladares, 2021). Jufrida et al., (2019) stated that having science literacy is essential to successfully face the challenges of the 21st century, because people who are science literate can use the knowledge, they have to solve problems and produce useful science products.

Students' science literacy skills can be influenced by community issues. According to Zeidler et al (2019), socioscientific problems can help students make better decisions about environmental issues and improve their ability to read. The influence of contextual factors both directly and indirectly on reading ability is influenced by the integration of information about sources and content in socioscientific problems (Garrecht et al., 2020).

Socio Scientific Issues are complex social problems with conceptual, procedural and/or technology associations with science, which will be encountered in everyday life (Sadler & Donnelly, 2006; Schenk et al., 2021). SSI is an approach that represents an issue or problem in social life that conceptually related to science (Hancock et al., 2019). In connection with the development of literacy science, SSI is the right context to achieve the expected goals (Yaumi & Taufikurohmah, 2019).

Learning socioscientific issues is very important to determine the context of science learning. SSI is an approach that aims to improve intellectual understanding, ethics, attitudes and awareness of the relationship between science and social life. By focusing on SSI, students are encouraged to try to relate the science knowledge they learn in class to social

issues around them. This helps students understand the material better as it is related to everyday life, which in turn can achieve biology learning objectives (Nurtamara, 2019).

Students' value in knowledge and perspectives on social science issues can be emphasized through the SSI approach (Herman et al., 2021). The context of SSI in learning starts with the surrounding environment and has reality and meaning in everyday life. For example, vaccines containing pork, which are forbidden by Islam, are an issue or subject of controversy in Indonesia (Dalaila et al., 2022). Teachers should choose the context of socioscientific issues carefully to ensure students have the necessary knowledge to argue (Kutluca, 2021).

One of the materials in learning the diversity of living things course in college, especially in the Tadris IPA study program at UIN Fatmawati Sukarno Bengkulu is biodiversity. Biodiversity education that is based on local potential should be implemented and developed by considering the diversity of natural resource potential in a region. Bengkulu as one of the provinces in Indonesia is one of the regions with a high and interesting level of biodiversity. Natural tourism in Bengkulu is diverse, such as mangrove forests, beaches, hot springs, forest tours, lakes and so on. The potential of local natural resources in Bengkulu can be used as a source of learning for students of various levels of education.

Biodiversity and local potentials material is very close to students' daily lives, so many social issues can be discussed in learning activities (Lindemann-Matthies, 2002; Mumpuni et al., 2022). Forest destruction, conversion, fires, and over-exploitation have attracted public attention and emerged as socioscientific issues (Wiyarsi & Çalik, 2019).

The goal of local potentials of biodiversity learning is to prepare students who have wisdom about the social, geographical, and cultural environment of the region, as well as foster attitudes and behaviors related to the preservation of existing resources in the region (Braun et al., 2018). This potential and local wisdom of the regions can be integrated in biology learning and poured in the form of teaching materials so as to create contextual learning and foster science literacy.

So far, biodiversity courses in Tadris IPA study program at UIN Fatmawati Sukarno Bengkulu still tend to examine textual problems presented to students theoretically, it has not been seen how students are forced to think deeply by analyzing biodiversity problems in the environment related to the theories they have previously obtained. Students were asked to complete questionnaires regarding the teaching materials used in biodiversity courses. The results indicate that 69.3% of the teaching materials were limited book packages with textual

discussions. Students are less able to comprehend the material and apply it in their daily lives because the examples of problems and the pictures are still typically not from the surroundings around them.

Rohmah et al (2022) mentioned that learning biodiversity material delivered by theoretical methods and utilization which is dominated by the description of the material causes students to be less enthusiastic and not actively involved in learning, because students are not responsive to problems that threaten biodiversity in nature.

Therefore, based on description above, the researchers tried to find a solution by developing an innovative learning media called socio-scientific issues (SSI) based on local potential biodiversity that can be used by teachers to help students become more science literate. Various previous studies have become the basis of reference for researchers in conducting this research such as research conducted by Hestiana & Rosana (2020) which states that innovative learning approaches such as socio-scientific issues (SSI) can be used by teachers to improve students' science literacy skills. Permanasari et al., (2021) in their research also found that the SSI approach in science learning makes students feel the need to learn science, and makes learning more meaningful. In addition, students' science literacy increased in the high category after implementation.

B. METHOD

The research methodology in this study using the Research and Development (R&D) approach. The model used in ADDIE development is Analyze, Design, Develop, Implementation, and Evaluation.

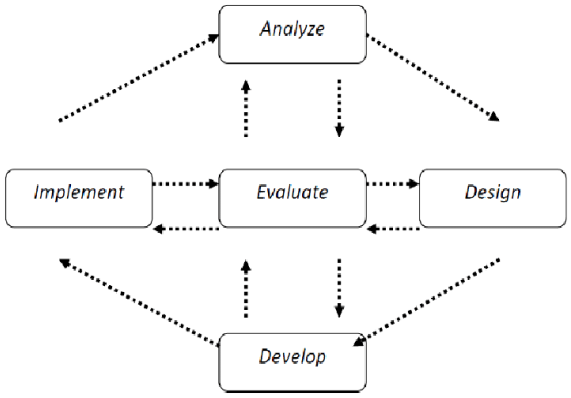

Figure 1. Stages of the ADDIE model (Richey & Klein, 2014)

The study specifically targets 37 fourth-semester students enrolled in the Tadris IPA Program at UIN Fatmawati Sukarno Bengkulu. The selection of research class subjects was

carried out through purposive sampling. Scientific literacy indicators are based on the criteria proposed by (Chiappetta & Fillman, 2007), encompassing science as a body of knowledge, science as a method of investigation, science as a mode of thinking, and the interplay of science, technology, and society. Data collected in this study include e-Module validity assessed through a validation questionnaire administered to material and media experts, practicality data obtained from student and teacher questionnaire responses, and effectiveness data involving science literacy scores and classical completeness.

The first stage in the research is the analysis stage, which consists of needs analysis and curriculum analysis. Needs analysis was obtained by observing and interviewing lecturer at Tadris IPA UIN Fatmawati Sukarno Bengkulu. *The second stage* is design, at this stage is done by compiling flowcharts as the basis for making e-Module development storyboards. The design stage outcomes are obtained by displaying the e-Module's contents and menu features which consists of the front page, home, introduction, learning outcomes (CP), indicators, and learning activities. *The third stage* is the development stage, where the content in the e-Module is developed to have specificity related to biodiversity material related to socio-science issues and local potential, including biodiversity problem in local area in Bengkulu Indonesia such as illegal logging, illegal fishing, a forest fires, lost biodiversity, and marine and coastal ecosystem damage. The e-Module contents developed follows the five stages of the SSI learning approach suggested by Marks et al., (2014), namely the section (1) What happens to our environment?, (2) Dig for more information!, (3) Think again!, (4) Let's Discuss!, and (5) Let's Reflect!.

Then, the validation process for this e-Module used were an expert validation questionnaire, a readability questionnaire, and science literacy test questions. Experts and practitioners assess teaching materials using a scale created by (Sugiyono, 2020), which has five categories of answer options, as shown in the following table.

Table 1. The Criteria of Expert and Practitioner Rating Interpretation

Criteria	Percentage
Very feasible	81% - 100%
Feasible	61% - 80%
Enough	41% - 60%
Less feasible	21% - 40%
Very infesible	0 % - 20%

The validation outcomes are employed to enhance or refine the previously developed module before subjecting it to trials or testing. During this phase, validation sheets are

provided to three designated validators for the evaluation of both the instruments and the module. Subsequently, adjustments are made to the instruments and the module in accordance with the inputs and recommendations provided by the validators. After having revision and improvement, the researchers do a consultation with the validators about the instruments and the module revision in order to determine the accuracy of the result of the revision.

The fourth stage is implementation which is carried out on the trial group by applying the e-module product to the learning process. Science literacy skills are measured during and after learning by using questions relevant to the e-module topic. *The fifth stage* of the ADDIE model in this study is an evaluation that aims to evaluate the feasibility and effectiveness of the developed teaching materials in improving student scientific literacy. Analysis of expert validation and readability data using descriptive quantitative percentage techniques.

The effectiveness of instructional materials is gauged through the analysis of student test scores. The evaluation of teaching material effectiveness employs the N-gain test, specifically designed to ascertain the augmentation in students' conceptual mastery.

Table 2. The Criteria for Gain Index

Score	Criteria
$g > 0,7$	High
$0,3 < g \leq 0,7$	Moderate
$g \leq 0,3$	Low

C. RESULTS AND DISCUSSIONS

The development of the biodiversity module, which focuses on socioscientific issues and local potential, involves presenting local issues in a discursive format. These issues are contextualized in everyday life, with a view to encouraging students to reflect on socioscientific issues prevalent in their environment. In addition, the module also seeks to foster students' ability to identify and propose solutions to related issues. The use of socio-scientific issues in learning makes it easier for students to understand the context of the lesson. According to Sadler & Zeidler (2009), socio-scientific issues can improve students reading literacy and critical thinking ability through discussion or debate activities in class. In line with Rohmah et al., (2021), e-module with characteristics of socio-scientific issues are able to improve critical thinking ability and scientific literacy students.

Validity and Practicality of SSI and local potential based e-Modules

Before the testing phase, the validity assessment of the e-Module involved examination by material expert validators, who assessed the e-Module content and science literacy

questions, as well as media expert validators, who focused on the design and practicality of the media. The validity analysis of the e-Module used a material validation questionnaire instrument consisting of four assessment components. The material aspect assessment includes introduction, content, learning activities, and language, while the media aspect assessment includes display, use, and utilization.

Table 3 below presents a brief overview of the results of the validation analysis related to biodiversity teaching materials based on Socioscientific Issues and local potential, which have been evaluated by experts and practitioners.

Table 3. Validation Results Based on Material and Media Experts

Experts	Assessment Indicator	Percentage Score	Criteria
Material	Introduction	88,7	Very feasible
	Content eligibility	85,3	Very feasible
	Learning activities	87,5	Very feasible
	Language eligibility	83,5	Very feasible
Average		86,3	Very feasible
Media	Appearance	91,5	Very feasible
	Use	89,3	Very feasible
	Utilization	86,7	Very feasible
Average		89,2	Very feasible

Based on Table 3 above shows that the average validity scores, as appraised by content experts across content feasibility, language eligibilty, and suitability of learning activities, are recorded at 86,3%, meeting the criteria for very feasible. This outcome signifies that both material expert validators and practitioners acknowledge that the comprehensiveness, scope, and depth of the instructional content within the developed teaching materials align with the learning outcomes (CP), competency standards (KD), learning objectives, and indicators for achieving the targeted competencies.

Material experts and practitioners concur that the content related to biodiversity within teaching materials is articulated in a communicative language, ensuring clarity, preventing ambiguity, and aligning with the developmental stage of students. This presentation approach facilitates a more comprehensive comprehension of the utilized instructional materials by students. El Shinta et al., (2020) asserts that the language utilized in educational materials should align with the proficiency level of higher education students, employing straightforward sentences devoid of complexity, and directly addressing the information to ensure ease of comprehension.

The presentation of scientific issues in teaching materials is considered feasible to be applied in learning activities because it has been accompanied by an affirmation of the five stages that are the criteria for SSI learning that can support intellectual development, communication skills, social attitudes, care and student participation. Forming the ability to

make decisions on social issues related to science and encouraging students to make connections between their knowledge and its application in everyday life. The five stages contained in these aspects cover all aspects of science literacy that are assessed so that students can train and improve their science literacy.

Based on Table 3, it is also known that media experts also state that teaching materials are very feasible to be applied in learning, with an average percentage value of 89,2%. Media experts and practitioners assess that the size of teaching materials has met ISO standards by using B4 paper size (250 x 353 mm). The cover design of the developed teaching materials is attractive because it contains titles, images that are in accordance with the theme of biodiversity related to socioscientific issues and local potential. The presentation of the layout has used a fairly interesting color combination, the font selection is also quite consistent. However, the media validator still directs not to use too many animated images that are less relevant to the study of the material. This is in line with the research of Kurniasih et al., (2020) which asserts that the inclusion of images in educational materials serves not only to elucidate the content but also to engender a sense of joy and ease for students in the process of studying the instructional materials. However, the selection of animation must also consider its relevance to the material described in the learning media.

Based on table 4 below, it can be seen that the results of the response test from media practitioners obtained a value of 88.3% which means very practical and feasible. Practitioners stated that this E-module can encourage students to carry out discussion activities. There are evaluation questions measuring scientific literacy related to scientific social issues and local potential that can be found in the community, so that students are able to reconstruct the concepts found through the process of critical thinking and problem solving. The presentation of the layout and color selection as well as font selection is also interesting and can provoke students' initial interest in learning. However, practitioners suggest that the fonts used can be slightly enlarged and the problems that become the topic of discussion are more relevant to the concept of local potential.

Chowdhury et al., (2020) and Nuangchalerm (2010) delineate that integration of SSI into a natural science learning, especially in the study of problematic and controversial issues in the concept of biodiversity can foster decision-making skills, improve scientific literacy, and enable intellectual growth, moral development and community engagement in local, social and global contexts.

Table 4. Practicality Test Results of Media Practitioner Response

Experts	Assessment Indicator	Percentage Score	Criteria
Practitioner	Learning media appearance	90,7	Very feasible
	Content eligibility	87,3	Very feasible
	Learning activities	86,5	Very feasible
	Language eligibility	88,5	Very feasible
Average		88,3	Very feasible

Effectiveness of SSI and local potential based e-Modules in improving scientific literacy skills

The effectiveness in this study is to evaluate the level of achievement through the utilization of e-Modules that have been developed in the learning process, especially in improving science literacy skills. The effectiveness analysis was conducted by utilizing the gain index, which was calculated from the comparison of pretest and posttest scores, and included the gain value. The results of the analysis of science literacy data at the pretest and posttest stages showed a difference, indicating an increase in value after the use of SSI and local potential based e-Modules. Table 5 shows a recapitulation of the description of the value data analysis N-gain for each aspect of scientific literacy assessed.

Based on the results of the N-gain analysis in Table 4 shows that the four aspects scientific literacy has increased in the moderate category. These results can be obtained because students learn to use teaching materials biodiversity based socio scientific issues that present clear and interesting learning material. The existence of a socio scientific issue approach in teaching materials allows students to make the right decisions, analyze, synthesize, and evaluate various issues that exist in society. Student experience in new and controversial issues in learning activities will foster skills scientific literacy.

Table 5. N-Gain Pretest and Posttest of Scientific Literacy Results

Scientific Literacy indicator	Mean Pretest	Mean Posttest	N-gain score	Criteria
Science as the body of knowledge	64,5	82,9	0,52	Moderate
Science as a way of inquiry	65,1	84,5	0,56	Moderate
Science as a way of thinking	62,1	83,4	0,49	Moderate
Interaction of science, technology and society	66,7	88,5	0,50	Moderate

According to the N-gain analysis results presented in Table 4, it is evident that the enhancement in the four aspects of scientific literacy falls within the moderate category. This outcome is attributed to students engaging with instructional materials grounded in biodiversity and socioscientific issues, which are characterized by lucid and compelling

learning content. The incorporation of a socioscientific issue approach into the instructional materials facilitates students in making informed decisions and enables them to analyze, synthesize, and evaluate various societal issues. Student experience in new and controversial issues in learning activities will foster skills scientific literacy (Ke et al., 2021; Sengul, 2019).

The process of examining diverse issues and challenges articulated in the *what happens to our environment?* section, particularly those related to our environment, and the subsequent reflection in the *Think again!* section within Socioscientific Issue (SSI)-based instructional materials, is designed to cultivate students' scientific literacy. This encompasses the development of proficiency in scientific thinking and the utilization of scientific methods for investigation. The enhancement of students' scientific literacy is facilitated through inclusive teaching practices that engage them in discussion activities and address queries presented in the *Dig for more information!* and *Think again!* sections, thus fostering a deeper understanding and application of science as a body of knowledge, a mode of thinking, and a method of inquiry.

The utilization of SSI based instructional materials on biodiversity within the educational framework contributes to the enhancement of scientific literacy skills within the context of science, technology, and societal interactions, yielding a moderate impact. This outcome is attributed to the inclusion of a dedicated section *Let's Reflect* in the instructional materials, encompassing activities pertinent to science and technology that hold practical relevance for the general public. Within this framework, students are systematically engaged in problem-solving exercises within their classroom and community environments, thereby honing their abilities to apply scientific and technological knowledge to address real-world challenges.

The use of learning materials oriented towards SSI during learning activities facilitates a more accessible understanding of biodiversity by students. Integrating problem scenarios and imagery sourced from the students' surrounding environment will create a contextualized atmosphere, thus increasing students' engagement in the learning process. According to Johnson et al., (2020), incorporating problems that align with students' life experiences can increase their interest, fostering active participation. This approach is essential in stimulating critical dialog and fostering students' scientific competence (Zeidler & Keefer, 2003).

In summary, the conducted research can be deemed efficacious in enhancing students' scientific literacy, as all four evaluated aspects of scientific literacy exhibited a noteworthy increase falling within the moderate category. Consequently, the introduction of biodiversity-focused Socio-Scientific Issue-based teaching materials represents an innovative approach to

biology education. This approach not only underscores the attainment of learning objectives but also emphasizes students' capacity to analyze, investigate, and articulate arguments, thereby fostering the development of independent scientific concepts. It is anticipated that such an approach will empower students to transcend theoretical knowledge, enabling them to comprehend the practical applications of scientific principles and contribute to addressing challenges within their respective environments.

D. CONCLUSION

Based on the research data analysis and subsequent discussion, it can be deduced that the utilization of biodiversity teaching materials grounded in socio-scientific issues and local potential is highly suitable for implementation in science education. The instructional materials exhibit a commendable feasibility level, meeting the criteria for good feasibility. This indicates that the teaching materials are readily comprehensible for students. Moreover, the developed teaching materials prove effective in enhancing four key facets of scientific literacy such as the body of knowledge, science as a way of investigation, science as a way of thinking and the interaction of science and technology and society.

REFERENCES

Braun, T., Cottrell, R., & Dierkes, P. (2018). Fostering changes in attitude, knowledge and behavior: Demographic variation in environmental education effects. *Environmental Education Research*, *24*(6), 899–920.

Chiappetta, E. L., & Fillman, D. A. (2007). Analysis of Five High School Biology Textbooks Used in The United States for Inclusion of The Nature of Science. *International Journal of Science Education*, *29*(15), 1847–1868.

Chowdhury, T., Holbrook, J., & Rannikmäe, M. (2020). Socioscientific Issues within Science Education and their Role in Promoting the Desired Citizenry. *Science Education International*, *31*(2), 203–208. https://doi.org/10.33828/sei.v31.i2.10

Dalaila, I., Widiyaningrum, P., & Saptono, S. (2022). Developing E-Module Based on Socio-Scientific Issues to Improve Students Scientific Literacy. *Journal of Innovative Science Education*, *11*(3), 285.

El Shinta, Z., Sunyono, S., & Setyorini, M. (2020). The Validity of the Online Module of Flipped Classroom Based on Socioscientific Issues Towards Students' Literacy Skills. *IOSR Journal of Research & Method in Education (IOSR-JRME)*, *10*(2), 51–56.

Garrecht, C., Eckhardt, M., Höffler, T. N., & Harms, U. (2020). Fostering Students' Socioscientific Decision-making: Exploring the Effectiveness of An Environmental Science Competition. *Disciplinary and Interdisciplinary Science Education Research*, *2*(1), 1–16.

Hancock, T. S., Friedrichsen, P. J., Kinslow, A. T., & Sadler, T. D. (2019). Selecting Socio-scientific Issues for Teaching: A grounded theory study of how science teachers collaboratively design SSI-based curricula. *Science & Education*, *28*, 639–667.

Herman, B. C., Newton, M. H., & Zeidler, D. L. (2021). Impact of Place-based Socioscientific Issues Instruction on Students' Contextualization of Socioscientific

Orientations. *Science Education*, *105*(4), 585–627.
Hestiana, H., & Rosana, D. (2020). The Effect of Problem Based Learning Based Sosio-Scientific Issues on Scientific Literacy and Problem-Solving Skills of Junior High School Students. *Journal of Science Education Research*, *4*(1), 15–21. https://doi.org/10.21831/jser.v4i1.34234
Hurd, P. D. (1998). Scientific Literacy: New Minds for a Changing World. *Science Education*, *82*(3), 407–416. https://doi.org/https://doi.org/10.1002/(SICI)1098-237X(199806)82:3<407::AID-SCE6>3.0.CO;2-G
Johnson, J., Macalalag, A. Z., & Dunphy, J. (2020). Incorporating socioscientific issues into a STEM education course: exploring teacher use of argumentation in SSI and plans for classroom implementation. *Disciplinary and Interdisciplinary Science Education Research*, *2*(1). https://doi.org/10.1186/s43031-020-00026-3
Jufrida, J., Basuki, F. R., Kurniawan, W., Pangestu, M. D., & Fitaloka, O. (2019). Scientific Literacy and Science Learning Achievement at Junior High School. *International Journal of Evaluation and Research in Education*, *8*(4), 630–636.
Ke, L., Sadler, T. D., Zangori, L., & Friedrichsen, P. J. (2021). Developing and Using Multiple Models to Promote Scientific Literacy in the Context of Socio-Scientific Issues. *Science and Education*, *30*(3), 589–607. https://doi.org/10.1007/s11191-021-00206-1
Kurniasih, N., Sunyono, & Herlina, K. (2020). Validity of Student Worksheets Based on Socioscientific Issues Towards improve Students' Literacy Skills. *IOSR Journal of Research & Method in Education (IOSR-JRME)*, *10*(2), 57–61. https://doi.org/10.9790/7388-1002045761
Kutluca, A. Y. (2021). An investigation of Elementary Teachers' Pedagogical Content Knowledge for Socioscientific Argumentation: The Effect of a Learning and Teaching Experience. *Science Education*, *105*(4), 743–775.
Lederman, N. G., Lederman, J. S., & Antink, A. (2013). Nature of Science and Scientific Inquiry as Contexts for the Learning of Science and Achievement of Scientific Literacy. *Online Submission*, *1*(3), 138–147.
Lindemann-Matthies, P. (2002). The Influence of An Educational Program on Children's Perception of Biodiversity. *The Journal of Environmental Education*, *33*(2), 22–31.
Marks, R., Stuckey, M., Belova, N., & Eilks, I. (2014). The Societal Dimension in German Science Education - from Tradition Towards Selected Cases and Recent Developments. *Eurasia Journal of Mathematics, Science and Technology Education*, *10*(4), 285–296. https://doi.org/10.12973/eurasia.2014.1083a
Mumpuni, K. E., Susilo, H., Rohman, F., & Ramli, M. (2022). Designing a module for learning plant biodiversity: An effort for conservation of local wisdom. *Biosfer: Jurnal Pendidikan Biologi*, *15*(1), 85–96.
National Academies of Sciences and Medicine, E. (2016). *Science Literacy: Concepts, Contexts, and Consequences*.
Nuangchalerm, P. (2010). Engaging students to perceive nature of science through socioscientific issues-based instruction. *European Journal of Social Sciences*, *13*(1), 34–37.
Nurtamara, L. (2019). The Importance Socio-scientific Issues of in Biology Learning Preparing Students as a 21st Century Society. *Journal of Physics: Conference Series*, *1157*(2), 22070.
Permanasari, A., Sariningrum, A., Rubini, B., & Ardianto, D. (2021). Improving Students' Scientific Literacy Through Science Learning with Socio Scientific Issues (SSI). *Proceedings of the 5th Asian Education Symposium 2020 (AES 2020)*, *566*(Aes 2020), 323–327. https://doi.org/10.2991/assehr.k.210715.068

Richey, R. C., & Klein, J. D. (2014). *Design and Development Research BT - Handbook of Research on Educational Communications and Technology* (J. M. Spector, M. D. Merrill, J. Elen, & M. J. Bishop (eds.); pp. 141–150). Springer New York. https://doi.org/10.1007/978-1-4614-3185-5_12

Rohmah, S. N., Iswari, R. S., & ... (2021). The Developing of Biodiversity Teaching Materials Based on Socio Scientific Issues to Improve Students' Science Literacy. *... of Innovative Science ...*, *11*(37), 183–192. https://journal.unnes.ac.id/sju/index.php/jise/article/view/51531%0Ahttps://journal.unnes.ac.id/sju/index.php/jise/article/download/51531/20229

Rohmah, S. N., Iswari, R. S., & Saptono, S. (2022). The Development of Biodiversity Teaching Materials Based on Socio Scientific Issues to Improve Students' Science Literacy. *Journal of Innovative Science Education*, *11*(2), 177–186. http://journal.unnes.ac.id/sju/index.php/jise

Sadler, T. D., & Donnelly, L. A. (2006). Socioscientific Argumentation: The effects of content knowledge and morality. *International Journal of Science Education*, *28*(12), 1463–1488. https://doi.org/10.1080/09500690600708717

Sadler, T. D., & Zeidler, D. L. (2009). Scientific literacy, PISA, and socioscientific discourse: Assessment for progressive aims of science education. *Journal of Research in Science Teaching*, *46*(8), 909–921. https://doi.org/10.1002/tea.20327

Schenk, L., Hamza, K., Arvanitis, L., Lundegård, I., Wojcik, A., & Haglund, K. (2021). Socioscientific Issues in Science Education: An opportunity to Incorporate Education about Risk and Risk Analysis? *Risk Analysis*, *41*(12), 2209–2219. https://doi.org/10.1111/risa.13737

Sengul, O. (2019). Linking scientific literacy, scientific argumentation, and democratic citizenship. *Universal Journal of Educational Research*, *7*(4), 1090–1098. https://doi.org/10.13189/ujer.2019.070421

Sugiyono. (2020). *Metode Penelitian Pendidikan Pendekatan Kuantitatif, Kualitatif, dan R&D*. Alfabeta.

Valladares, L. (2021). Scientific Literacy and Social Transformation: Critical Perspectives about Science Participation and Emancipation. *Science & Education*, *30*(3), 557–587.

Wiyarsi, A., & Çalik, M. (2019). Revisiting the scientific habits of mind scale for socio-scientific issues in the Indonesian context. *International Journal of Science Education*, *41*(17), 2430–2447.

Yaumi, Y., & Taufikurohmah, T. (2019). Development of science learning material with socio-scientific issues (ssi) on climate change materials to improve science literacy of junior high school students. *Jurnal Penelitian Pendidikan IPA*, *4*(2), 56–63.

Zeidler, D. L., Herman, B. C., & Sadler, T. D. (2019). New Directions in Socioscientific Issues Research. *Disciplinary and Interdisciplinary Science Education Research*, *1*(1), 1–9.

Zeidler, D. L., & Keefer, M. (2003). *The Role of Moral Reasoning on Socioscientific Issues and Discourse in Science Education*.