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The Development of Interactive Multimedia Based on Mini Research Projects Integrated with Socio-Scientific Issues (SSI) as a Means of Improving Science Literacy

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Abstract. *This study aimed to develop an interactive multimedia product entitled AKSI BUMI (Aplikasi Riset Berbasis Lingkungan Masa Kini) based on Mini Research Project integrated with Socio-Scientific Issues (SSI) on Environmental Issues material for ninth-grade junior high school students, and to examine its effectiveness in improving science literacy. The study employed the Lee & Owens development model consisting of five stages: analysis, design, development, implementation, and evaluation, with Canva for Education as the development platform. Content validity was assessed by a subject matter expert, yielding a score of 96% (Very Valid), while media validity reached 100% (Very Valid) based on Mayer's twelve principles of multimedia learning. Practitioner assessment also achieved 100%, and student responses were consistently rated at 91% across both small-group and large-group trials. Effectiveness was measured using a pretest-posttest design with N-Gain Score analysis involving 20 students of SMPN 28 Batanghari. Results showed an average N-Gain Score of 0.7458, categorized as High based on Melzer's classification, with an effectiveness percentage of 74.58%, approaching the Effective threshold according to Hake's criteria. These findings suggest that the integration of Mini Research Project and SSI within an interactive multimedia platform constitutes a valid, practical, and effective instructional approach for enhancing science literacy in the context of environmental issues learning at the junior high school level.*

Keywords: *Interactive Multimedia; Mini Research Project; Science Literacy; Socio-Scientific Issues; Environmental Issues.*

Abstrak. Penelitian ini bertujuan mengembangkan multimedia interaktif AKSI BUMI (Aplikasi Riset Berbasis Lingkungan Masa Kini) berbasis Mini Research Project terintegrasi Socio-Scientific Issues (SSI) pada materi Isu Lingkungan untuk peserta didik kelas IX SMP, sekaligus menguji efektivitasnya terhadap peningkatan literasi sains. Pengembangan dilakukan menggunakan model Lee & Owens melalui lima tahap: analisis, perancangan, pengembangan, implementasi, dan evaluasi, dengan platform Canva for Education sebagai medium produksi. Validasi ahli materi menghasilkan persentase kelayakan sebesar 96% (Sangat Valid), validasi ahli media mencapai 100% (Sangat Valid) berdasarkan dua belas prinsip pembelajaran multimedia Mayer, penilaian praktisi sebesar 100%, serta respons peserta didik yang konsisten di angka 91% pada uji coba kelompok kecil maupun kelompok besar. Efektivitas diukur menggunakan desain *pretest-posttest* dengan analisis N-Gain Score pada 20 peserta didik SMPN 28 Batanghari, menghasilkan nilai rata-rata N-Gain sebesar 0,7458 (kategori Tinggi berdasarkan klasifikasi Melzer) dengan persentase efektivitas 74,58% yang sangat mendekati ambang kategori Efektif menurut kriteria Hake (1999). Temuan ini mengindikasikan bahwa integrasi MRP dan SSI dalam platform multimedia interaktif merupakan pendekatan yang valid, praktis, dan efektif dalam meningkatkan literasi sains peserta didik pada materi Isu Lingkungan di jenjang SMP.

Kata kunci: Isu Lingkungan; Literasi Sains; Mini Research Project; Multimedia Interaktif; Socio-Scientific Issues.

1. BACKGROUND

The challenge of science education in the 21st century no longer requires just mastery of scientific content, but requires the formation of individuals who are able to use scientific knowledge to understand natural phenomena, critically evaluate evidence, and make data-driven decisions on complex social and environmental issues (Gege Dodik Sanjiartha et al., 2024). This competency is academically known as science literacy. The Programme for

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International Student Assessment (PISA) organized by the Organisation for Economic Co-operation and Development (OECD) has consistently made science literacy one of the main domains of measuring the ability of students across countries. Unfortunately, the latest data shows that Indonesia's position in this domain is still far from satisfactory (Abrori et al., 2024). Based on the OECD report (2023), the average science literacy score of Indonesian students in PISA 2022 was recorded at 383, a significant decrease compared to the 2018 score of 396, or a learning loss of 13 points. Furthermore, the score is still far below the average of OECD countries which reaches 485 points, placing Indonesia in the 68th position out of 81 participating countries (OECD, 2023). This condition indicates a fundamental structural problem in the science learning ecosystem in Indonesia.

The phenomenon of the gap in education quality is also specifically illustrated at the research location, namely SMP Negeri 28 Batanghari. Based on data from the Education Report Card for the past three years, students' literacy ability fluctuated in the medium category (59.52%, 51.11%, 60.53%) without a significant spike, showing that students' literacy ability fluctuated in the medium category without a significant spike, while numeracy ability despite increasing from the less category will decline again in 2025. This data indicates that there are structural problems in the science learning ecosystem, where the methods applied have not been effective in boosting students' basic competencies. Especially in the Science curriculum for Grade 9 Junior High School, environmental issues material has high urgency. This material covers environmental health in Indonesia, global warming, energy crisis and food availability. This topic is very relevant to daily life but is often considered abstract by students, especially related to the mechanisms of the greenhouse effect or the invisible cycle of pollutants. Mastery of this material is vital so that students not only understand the concept, but also be able to act as agents of environmental change (Danhas & Danhas, 2024).

However, the initial needs analysis shows a serious gap in understanding. As many as 57.1% of students stated that it was difficult to understand the complexity of environmental issues if they only relied on verbal explanations. On the other hand, 90.4% of students believe that the use of visual media (animation/simulation) will greatly help their understanding. This data confirms the inefficiency of conventional learning in visualizing complex ecological concepts. In addition, even though environmental practicum activities have been carried out, students often fail to connect the observation data with science concepts, indicating the need for more structured research guidelines in improving students' science literacy.

This condition demands a learning approach that not only presents content, but also facilitates meaningful scientific investigation. One approach that has consistently proven effective for this is the integration of Socio-Scientific Issues (SSI) into the learning process. SSI is an issue that is controversial, contextual, and closely related to science, technology, the environment, as well as the social and ethical dimensions in people's lives (Sadler, 2011; Zeidler & Sadler, 2023). Through the SSI approach, students not only learn to understand scientific concepts, but are also trained to use this knowledge in responding to real problems that are multidimensional.

A meta-analysis study conducted by Usman et al. (2024) on 27 empirical studies found that the use of SSI-based electronic media significantly increased students' science literacy with an average effect size of 0.82, which is classified as strong. Furthermore, research from Anggereini et al. (2023) confirms that the implementation of SSI-based learning and project-based learning (PjBL) has great potential in developing contextual science literacy. The SSI approach has been specifically shown to train learners to think critically, make evidence-based arguments, and build social awareness of environmental issues relevant to their lives (Viehmann et al., 2024).

In addition to the SSI approach, digital technology-based learning media innovations also play a central role in boosting the effectiveness of science learning. A number of empirical studies prove that the use of interactive multimedia consistently has a positive impact on students' understanding of concepts and active involvement in learning (Yudhistira et al., 2022). Interactive multimedia allows the presentation of scientific information through an integrated combination of text, images, animations, videos, and exploratory activities, thus in accordance with the principles of the Cognitive Theory of Multimedia Learning (CTML) developed by Mayer (2009). This principle confirms that information processing will be more optimal when material is presented through two cognitive channels simultaneously, namely the verbal channel and the visual channel. Meanwhile, the Mini Research Project (MRP) offers a different but complementary pedagogical dimension. Through MRP, students are guided to undergo a simple scientific investigation experience independently, starting from problem identification, hypothesis formulation, data collection, result analysis, to conclusion preparation. Anggereini et al. (2023) proved that the implementation of the Mini Research Project has proven to be effective in shaping pro-environmental behavior and significantly improving students' scientific thinking skills.

Although previous research has explored each of these components separately, there is a significant research gap related to the development of interactive multimedia that explicitly integrates the Mini Research Project's syntax with the context of SSI as a whole, scalable instructional design unit. Most previous research has been limited to text-based or discussion-based SSI implementation trials, without integrating structured scientific research activities into accessible digital media platforms. In addition, the development of SSI-based multimedia that is interactive multimedia that combines research simulations with socio-scientific issues is still very rarely explored. Therefore, this study aims to develop an Interactive Multimedia Based on the Integrated Socio-Scientific Issues (SSI) Mini Research Project on Environmental Issues material for students. So that this innovation can be tested its effectiveness in improving science literacy and practically as a solution to improve the quality of science learning at SMP Negeri 28 Batanghari.

2. THEORETICAL STUDIES

Interactive Multimedia

Interactive multimedia is defined as a learning medium that integrates text, images, animations, videos, and exploratory activities in one digital platform that allows users to control their flow and learning speed independently (Vaughan, 2014). In the context of science education, interactive multimedia functions not just as a content presenter, but as a *cognitive tool* that facilitates the active construction of knowledge (Yudhistira et al., 2022).

The theoretical foundation of multimedia development in this study refers to the *Cognitive Theory of Multimedia Learning* (CTML) developed by Mayer (2009). This theory asserts that humans have two information processing channels that work in parallel: the verbal channel and the visual channel with limited capacity. Information processing will be more optimal when material is presented simultaneously through both channels rather than just one channel (Damanik & Fajari, 2025). Based on this principle, Mayer (2009) formulated twelve multimedia design principles that are the reference for product development in this study, including the principles of coherence, marking, spatial and temporal contiguity, segmentation, modality, redundancy, and personalization.

Mini Research Project (MRP)

The Mini Research Project (MRP) is a small-scale scientific inquiry-based learning approach designed so that students can actively construct their knowledge through a simple, structured research experience (Anggereini et al., 2023). In contrast to conventional learning

that places students as passive recipients of information, MRP provides autonomy to students to identify contextual problems, formulate hypotheses, collect and analyze data, and draw conclusions based on empirical evidence (Yulianingsih, 2018).

The MRP stage basically follows a simplified scientific method procedure, including problem identification, hypothesis formulation, research planning, data collection, data analysis, and drawing conclusions and reflection (Madhani et al., 2025). The direct involvement of students in each of these stages has been proven to consistently form scientific thinking skills, improve analytical skills, and foster scientific attitudes that cannot be obtained through textual learning alone (Anggereini et al., 2023). In the context of this research, MRP is integrated into multimedia as the main learning syntax that guides learners to conduct simple scientific investigations virtually into real environmental issues.

Socio-Scientific Issues (SSI)

Socio-Scientific Issues (SSI) are real issues that are controversial and multidimensional, where science is the main component in understanding and solving them but at the same time involves complex social, ethical, political, and moral dimensions (Smit et al., 2025). SSI covers topics such as climate change, energy crisis, environmental pollution, and food security issues that are relevant to students' lives but do not have a single, simple solution.

Through the SSI approach, learners not only learn to understand scientific concepts procedurally, but are also trained to actively use them to evaluate real dilemmas, make evidence-based arguments, and make decisions that consider the ethical and social dimensions simultaneously (Viehmann et al., 2024). A meta-analysis study by Usman et al. (2024) on 27 empirical studies found that SSI-based learning media increased science literacy with an average *effect size* of 0.82, which is classified as strong. The SSI approach is particularly effective in building students' social awareness of the impact of science application in society, as well as training critical thinking skills and scientific argumentation which are core components of contextual science literacy (Anggereini et al., 2023).

Science Literacy

Science literacy is defined as the ability to use scientific knowledge to explain natural phenomena, critically evaluate evidence, and make data-driven decisions on complex social and environmental issues (OECD, 2023). In this sense, science literacy is not just the mastery of scientific content, but the capacity to act as a critical and reflective citizen of science problems in real life (Gege Dodik Sanjiartha et al., 2024).

Science literacy competencies include three main dimensions: the ability to explain phenomena scientifically, the ability to construct and evaluate scientific inquiry designs and interpret data critically, and the ability to use scientific information for decision-making and real action (Safitri & Saari, 2023). These three dimensions cannot be developed through rote learning alone, but require contextual, investigative, and real-issue learning experiences. PISA 2022 data shows that the average science literacy score of Indonesian students of 383 is far below the OECD average of 485, indicating a significant gap between actual achievement and expected competence (OECD, 2023). This condition emphasizes the urgency of developing a learning approach that explicitly targets the improvement of the three dimensions of science literacy competencies in an integrated manner.

3. RESEARCH METHODS

This research uses research *and development* (R&D), which aims to produce interactive multimedia based on Mini Research Project (MRP) integrated Socio-Scientific Issues (SSI) on Environmental Issues material. Located at SMP Negeri 28 Batanghari, in the period of October 2025 – May 2026 for grade IX junior high school students. The development model used is the Lee & Owens (2004) model which consists of five stages: *analysis, design, development, implementation,* and *evaluation.*

The analysis stage includes analysis of needs, characteristics of students, learning objectives, materials, media, and educational technology which is carried out through field observations, questionnaires, and interviews with science teachers at SMP Negeri 28 Batanghari. The design stage includes the preparation of material structures, *flowcharts*, and *storyboards*. The product was developed using the Canva for Education platform with reference to the principles *of Cognitive Theory of Multimedia Learning* (Mayer, 2009).

Product feasibility is assessed through validation of subject matter experts and media experts using a Likert scale of 1–5, with a minimum feasibility threshold of 61%. The trial was conducted in two stages: a small group trial (10–15 students) and a large group (one full class). The effectiveness of the product was measured using *a pretest-posttest design* with N-Gain Score analysis to determine the improvement of students' science literacy, based on Melzer's criteria (high: >0.7; medium: 0.3–0.7; low: <0.3) and Hake's (1999) interpretation of effectiveness. The research data consisted of qualitative data in the form of suggestions from experts and teachers, as well as quantitative data in the form of validation scores, student

responses, and results of SSI-based science literacy tests in the form of contextual description questions.

4. RESULTS AND DISCUSSION

Based on the findings obtained, the researcher presented the findings of the development of interactive multimedia developed with the title AKSI BUMI (Current Environment-Based Research Application), which is a web-based learning media developed using the Canva for Education platform by integrating the syntax of the Mini Research Project (MRP) and the Socio-Scientific Issues (SSI) approach in the Environmental Issues material for grade IX of junior high school. Product testing is carried out in stages including validation of material experts, validation of media experts, practitioner assessments, student response tests, and measurement of product effectiveness to improve science literacy through *pretest-posttest* design with N-Gain Score analysis. As follows:

Subject Matter Expert Validation

The feasibility of AKSI BUMI's interactive multimedia content is assessed through a theoretical validation process, to ensure academic quality standards before being tested. Validation was carried out in two rounds using assessment instruments based on the Likert scale 1 to 5 which included five aspects, namely curriculum suitability, concept correctness, relevance of Socio-Scientific Issues (SSI), language, and science literacy competency support.

Table 1. Recapitulation of Material Expert Validation Results

Assessment Aspects	Validation I	Validation II
Curriculum Fit	3,67	5,00
Concept Truth	3,25	4,75
Relevance of SSI	3,33	5,00
Language	3,00	4,33
Science Literacy Competency Support	4,00	4,67
Total Score	55	77
Average	3,44	4,81
Eligibility Percentage	69% (Fairly Valid)	96% (Very Valid)

Source: Data processed (2026)

Based on the data in Table 1, there was a significant improvement in content quality between the two rounds of validation. In Validation I, multimedia obtained a total score of 55 with an average of 3.44 and a feasibility percentage of 69%, which is included in the *Quite Valid category*. The validator provided a number of substantial improvement notes, including the need to restructure the syntax flow of the mini research project, the addition of a variety of socio-scientific issues so that students can choose topics that are relevant to their respective

environmental contexts, and the insertion of waste inventory table format in the digital E-LKPD. After a thorough revision according to the recommendations, Validation II produced a very sharp spike with a total score of 77, an average of 4.81, and a feasibility percentage of 96%, which placed the product in the *Very Valid category*.

The achievement of 96% content validity shows that all environmental issue material content presented in multimedia is perfectly aligned with the Learning Outcomes (CP) Phase D of the Independent Curriculum, is free from scientific misconceptions, and has sufficient socio-scientific dilemma content to trigger students' critical reasoning. These findings are in line with the principle of instructional content validity which states that the feasibility of a learning medium is largely determined by the consistency of the material with the learning objectives and the depth of the presentation of concepts that are in accordance with the level of cognitive development of students (Anggereini, Yelianti, et al., 2023). The two-round validation process carried out in this study also proves that the iterative revision mechanism is an effective development procedure in systematically improving product quality.

Validation of Media Experts and Practitioners

Assessments of visual architecture and multimedia interactive design are carried out by media experts, to ensure academic quality standards before being piloted. Mused an instrument based on 12 Richard E. Mayer Multimedia Learning Principles as an evaluation framework. The selection of this instrument is based on the theoretical foundation that multimedia designed in accordance with the principles of the Cognitive Theory of Multimedia Learning (CTML) will minimize the extra cognitive load of learners and optimize the processing of information through two sensory channels simultaneously (Mayer, 2009).

Table 2. Recapitulation of Media Expert Validation Results and Practitioner Assessment

Appraiser	Validation/Assessment	Total Score	Average	Percentage	Categories
Media Member	Validation I	57	4,75	95%	Highly Valid
Media Member	Validation II	60	5,00	100%	Highly Valid
Science Practitioners/Teachers	Single Assessment	60	5,00	100%	Very Practical

Source: Data processed (2026)

The results of media validation in the first round showed a very high achievement, namely a total score of 57 with a percentage of 95% (Very Valid). Validators provide minor feedback in the form of adjusting images that don't align with the learning theme, rearranging the navigation buttons to make them more intuitive, and adding audio elements to emphasize some content segments. After improvement, Validation II resulted in a perfect score of 60 with an average of 5.00 and a percentage of 100%, which means that all 12 Mayer principles have been optimally met. The achievement of 100% media validity confirms that AKSI BUMI multimedia has met the criteria of *Coherence* (free from distraction elements), *Signaling* (precise visual emphasis), *Segmenting* (flexible navigation control), and *Personalization* (communicative language style) as a whole.

This theoretical validity is strengthened by the practical assessment of the field practitioners, together with science teachers of SMPN 28 Batanghari. The teacher gave a perfect score of 5 on all 12 items of the Mayer indicator, resulting in a 100% practicality percentage without a single revision note. This assessment confirms that AKSI BUMI multimedia is not only theoretically feasible, but also applicative, adaptive, and ready to be implemented in real learning settings in the classroom. The highest media validity score achieved is consistent with the research of Yudhistira et al. (2022) which confirms that interactive multimedia based on the CTML principle has proven to be effective in increasing students' active involvement in science learning because it is able to present information in a dual-coding manner through verbal and visual channels simultaneously.

Student Responses

The acceptability and practicality of AKSI BUMI interactive multimedia by end-users was tested through two stages of field trials. The first phase of the trial involved 6 students (small groups) who were purposively selected based on the diversity of academic abilities, while the second phase of the trial involved 20 students in one full class (large group). These two trials used a response questionnaire that included three aspects of assessment, namely Presentation Techniques, Presentation Support, and Material Presentation.

Table 3. Recapitulation of Student Responses to Small and Large Group Trials

Assessment Aspects	Small Group (n=6)		Large Group (n=20)	
	Average	Percentage	Average	Percentage
Serving Techniques	4,39	88%	4,58	92%
Presentation Support	4,42	88%	4,48	90%
Ingredient Presentation	4,83	97%	4,57	91%
Overall	4,56	91%	4,55	91%

Source: Data processed (2026)

The data in Table 3 show a very strong consistency of multimedia performance between the two stages of the trial. In the small group trial, multimedia obtained an overall average of 4.56 with a percentage of 91% (Excellent). The aspect of Material Presentation recorded the highest score of 4.83 (97%), which indicates that the visualization of infographics, embedded YouTube videos, and the presentation of environmental content in a contextual manner succeeded in triggering students' interest in independent learning optimally. This consistency was evident in large group trials with almost identical overall average gains, which was 4.55 with a percentage of 91% (Excellent). The stable response percentage between small and large groups is a strong indicator of product reliability, indicating that the quality of the learning experience offered by this multimedia does not depend on the scale of the user.

Students consistently stated that the web-based button navigation in Canva was very responsive, the transition between menus from the Issues Gallery to the Research Room was intuitive, and the presentation of controversial socio-scientific issues was able to provoke active and substantial group discussions. This finding is relevant to the results of a study by Anggereini et al. (2023) which confirmed that learning media that integrates real social-scientific issues consistently received a more positive response from students because it presents personal relevance to the environmental problems they face daily, thereby directly increasing their intrinsic motivation and cognitive involvement in the learning process.

The Effectiveness of Multimedia in Improving Science Literacy

Science literacy was carried out using a pretest-posttest design on 20 students in grade IX of SMPN 28 Batanghari. Before the N-Gain analysis is performed, the prerequisites for normal distribution are first met through the Shapiro-Wilk test using SPSS. The test results showed a significance value (Sig.) for the science literacy pretest of 0.101 and the science literacy posttest of 0.062, both of which were above the alpha value of 0.05, so that the data was declared to be normally distributed and valid to proceed to the effectiveness analysis.

Table 4. Recapitulation of Science Literacy Pretest, Posttest, and N-Gain Score Results

Descriptive Statistics	Pretest	Posttest	N-Gain Score
Minimum Score	17	67	-
Maximum Value	67	100	-
Average	44,75	84,65	0,7458
N-Gain Percentage	-	-	74,58%
Categories	-	-	High (Effective)

Source: Data processed (2026)

Based on Table 4, the average score of the students' science literacy pretest before treatment was 44.75, which reflects the relatively low competency baseline condition. After using AKSI BUMI's interactive multimedia for three meetings that were integrated with the Mini Research Project syntax and the SSI approach, the average posttest score jumped to 84.65. From this difference in increase, the results of the N-Gain Score analysis showed an average value of 0.7458 or 74.58%. Referring to Melzer's classification criteria in Novita et al. (2019), the N-Gain value of 0.7458 falls into the High category because it exceeds the threshold of 0.7. Meanwhile, based on the interpretation of Hake (1999) effectiveness, the percentage of 74.58% is in the Quite Effective category. These two references measure different but complementary aspects: Melzer's classification suggests that the magnitude of the increase is relatively high, while Hake's interpretation indicates that the effectiveness of the intervention is very close to the threshold of the Effective category (>75%). Overall, these findings indicate that AKSI BUMI's interactive multimedia has a significant and meaningful impact on improving students' science literacy.

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These findings reinforce and expand the results of a meta-analysis conducted by Badeo et al. (2022) who found that the implementation of SSI in science learning resulted in an overall effect size of 1.08 (large category) with the greatest effect on the dimensions of decision-making and scientific content. An interesting difference is that this study not only tests SSI in a text discussion format, but integrates it into a web-based interactive multimedia platform that

allows students to conduct mini-research virtually, thus offering a more comprehensive approach than conventional SSI implementations in the literature.

So through the observations made, it shows that AKSI BUMI's interactive multimedia meets the three main criteria for the success of R&D products simultaneously, namely valid, practical, and effective. Content validity reaching 96% and media validity reaching 100% confirm that the product has met the theoretical feasibility standards before implementation. The practicality evidenced by a 100% practitioner assessment and a consistent student response of 91% in both stages of the trial show that the product is not only academically feasible, but also accessible and acceptable to users in the field. At its peak, the effectiveness shown through the N-Gain Score of 0.7458 (High category) confirms that the integration of MRP and SSI in interactive multimedia platforms is able to drive meaningful increase in science literacy. This finding directly answers the research gap identified in this study, that the development of multimedia that explicitly combines the syntax of the Mini Research Project with the context of SSI as a unit of instructional design has proven to be a valid, practical, and effective approach in improving the science literacy of junior high school students on Environmental Issues material.

5. CONCLUSIONS AND SUGGESTIONS

Drawing on the results of this research, the researcher can state that this research has succeeded in developing an interactive multimedia AKSI BUMI (Current Environment-Based Research Application) based on the Mini Research Project integrated with Socio-Scientific Issues (SSI) on Environmental Issues material for grade IX students of SMP Negeri 28 Batanghari, using the Lee & Owens development model through the Canva for Education platform. The resulting product was declared theoretically feasible based on the validation of material experts with a feasibility percentage of 96% (Very Valid) and the validation of media experts with a percentage of 100% (Very Valid), and was proven practical through a practitioner assessment of 100% and consistent student responses of 91% in small group and large group trials.

Effectiveness testing using a pretest-posttest design showed an increase in science literacy with an average N-Gain Score of 0.7458, which is included in the High category based on Melzer's classification, although based on Hake's (1999) interpretation, the effectiveness of the intervention was in the Quite Effective category with a percentage of 74.58% which is very close to the threshold of the Effective category. These findings indicate that the integration of

MRP and SSI in interactive multimedia platforms is a valid, practical, and effective approach in improving students' science literacy, especially in the context of learning Environmental Issues at SMPN 28 Batanghari. Given the limitations of the study involving only 20 students in one school, the generalization of these findings needs to be done with caution. Follow-up research with a larger sample, more rigorous experimental design, and testing in diverse school contexts is strongly recommended to reinforce the external validity of these findings.

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