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EFFECTIVENESS OF E-MEDIA ON SSI TO INCREASING STUDENTS' SCIENTIFIC LITERACY - META-ANALYSIS

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Abstrak
Mata pelajaran IPA membutuhkan berbagai media pembelajaran sebagai penunjang untuk mempermudah siswa memahami konsep yang diajarkan. Tanpa dukungan media pembelajaran yang tepat, materi IPA sering kali sulit dipahami dengan baik. Media pembelajaran yang efektif meliputi media interaktif berbasis teknologi maupun media visual yang membantu visualisasi konsep. Penelitian ini bertujuan untuk menganalisis pengaruh media pembelajaran berbasis *Socio-Scientific Issues* dalam meningkatkan literasi sains siswa. Metode penelitian yang digunakan adalah meta-analisis dengan melakukan kajian terhadap artikel dari jurnal nasional dan internasional yang relevan. Data yang dianalisis berupa hasil pretest dan posttest siswa, serta uji *N gain* untuk mengukur peningkatan literasi sains. Analisis data kuantitatif dilakukan untuk menentukan efektivitas media pembelajaran berbasis SSI terhadap literasi sains. Berdasarkan hasil meta-analisis, mengindikasikan bahwa penggunaan media berbasis SSI sangat efektif dalam meningkatkan literasi sains siswa pada berbagai jenjang pendidikan.

Kata Kunci: Media Pembelajaran; *Socioscientific Issue*; Literasi Sains; Meta Analisis

Abstract
Science subjects require a variety of learning media as support to make it easier for students to understand the concepts taught. Without the support of the right learning media, science material is often difficult to understand properly. Effective learning media include technology-based interactive media and visual media that help visualize concepts. This study aims to analyze the effect of socio-scientific issues based learning media in improving students' science literacy. The research method used is meta-analysis by reviewing articles from relevant national and international journals. The data were analyzed in the form of students' pretest and posttest results, as well as the N gain test to measure the improvement of science literacy. Quantitative data analysis was conducted to determine the effectiveness of SSI-based learning media on science literacy. Based on the results of the meta-analysis, it indicates that the use of SSI-based media is very effective in improving students' science literacy at various levels of education.

Keyword*: Educational Media; Socioscientific Issues; Scientific Literacy;Meta-analysis.*

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INTRODUCTION

The exigencies of 21st-century education necessitate that educators cultivate students' critical and creative thinking abilities to navigate this era. Education emphasizes mastery of science and technology, as well as critical thinking skills and competitiveness, to align with global demands (Karlina & Abidin, 2022). Scientific literacy skills are essential to meet the challenges of the 21st century.

Scientific literacy is a fundamental competency that students must possess to comprehend natural phenomena rationally and responsibly while addressing the escalating social, economic, and environmental challenges. Scientific literacy is the individual capability to address problems, interpret scientific phenomena, acquire knowledge, and formulate solutions and decisions grounded in data and science (OECD, 2023) . Scientific literacy necessitates that individuals enhance their understanding of scientific principles and methodologies when making decisions and engaging in the social, cultural, and economic spheres. The implementation of scientific literacy occurs not only in college education but also throughout one's lifetime (Permanasari et al., 2021). Scientific literacy is crucial as it aids individuals in critical thinking, decision-making, and problem-solving (Chusni & Hasanah, 2018). Scientific literacy is crucial for fostering developmental attitudes, environmental awareness and responsibility, as well as enhancing student interest, motivation, and engagement (Oliver & Adkins, 2020). Science is intricately connected to daily life (Suryanti et al., 2021). Consequently, scientific literacy can enhance students' knowledge, skills, and attitudes regarding science and technology education, while also fostering environmental consciousness to address the challenges of the 21st century.

The PISA assessments of 2015, 2018, and 2022 indicate a notable decline in the reading literacy skills of Indonesian students. In 2015, the science score was 397, subsequently decreasing to 371 in 2018, and further declining to 359 in 2022. This persistent decline poses significant obstacles to enhancing scientific literacy among Indonesian students. Regrettably, the mean science literacy score of OECD nations in 2018 was 489, whereas Indonesia lagged significantly with a disparity of 93 points. In 2022, Indonesian students' science literacy score will be comparatively low, exhibiting a disparity of 96 points from the OECD average of 485. This data underscores the substantial disparity in science literacy performance between Indonesia and OECD nations (OECD, 2023). The PISA results indicate that the government has failed to meet the anticipated science literacy score target. Indonesia's current score of 389 remains significantly below the 2020-2024 RPJMN target of 402, falling short by 13 points. This gap exemplifies the significant challenges that must be addressed to enhance scientific literacy in Indonesia.

In the majority of educational settings, the learning process focuses solely on the ability to memorize information. Learners are only concerned with remembering and hoarding information, rather than understanding how to apply it to real-world situations (Mareti & Hadiyanti, 2021) . Learning that only memorizes concepts does not result in a thorough understanding of the concepts (Dewanti, 2018). If this is not addressed, students will struggle to understand concepts in the following material (Ruci et al., 2023). Conventional learning models that are more instructive, lecture-based, and teacher-centered frequently fail to engage students in meaningful and interactive learning (Usman et al., 2023). As a result, students often memorize facts and concepts without fully understanding their practical applications. This approach also impedes the development of scientific literacy skills such as problem solving, data interpretation, and evidence-based decision making. Indeed, science literacy is an important skill for dealing with a variety of current issues that frequently have a direct impact on daily life, such as environmental pollution, climate change, and the energy crisis (Ayu, 2024).

To increase scientific literacy, diverse methodologies and strategies may be employed in education. An effective strategy is to connect scientific concepts with real-world situations (Widodo et al., 2020). This step facilitates students' recognition of the relevance of science in daily life, thereby aiding the application of scientific knowledge. Furthermore, the Socio-Scientific Issues (SSI) approach has demonstrated efficacy in enhancing scientific literacy. SSI is a methodology that amalgamates social and scientific dimensions to enhance the examination and discourse of scientific matters within a societal framework (Sadler & Dawson, 2012). This method enhances students' comprehension of scientific principles, fosters critical thinking, and promotes evidence-based decision-making (Sadler, 2011). Through SSI, students are anticipated to be more equipped to confront global challenges and contribute to scientific resolutions.

The implementation of the SSI issue approach alone is inadequate for enhancing the cognitive abilities of 21st-century students; therefore, a strategy involving the utilization of appropriate learning media and resources is essential. Such media should facilitate the transition from concrete to abstract thinking, capture students' attention, and aid in their comprehension, thereby rendering the learning experience more meaningful (Laksono & Wibowo, 2022) (Rokhim, et al, 2020). The appropriate selection of learning media, considering the suitability and experience of students, can engage their interest and enhance the clarity of the included subjects (Rahma, 2019). SSI is open-ended, indicating multiple potential solutions without a definitive answer (Topcu, 2010; Zeidler et al., 2011). The incorporation of SSI in science education enhances the learning experience by linking scientific principles to societal issues. This method enables students to analyze scientific data, critically assess it, and make evidence-based decisions (Bossér et al., 2015).

At its essence, science education entails the amalgamation of diverse disciplines through the connection of scientific principles to real-world contexts (Fajrie & Masfuah, 2018; Fakhriyah et al., 2023). The Socio-Scientific Issues (SSI) approach is highly appropriate for addressing contemporary societal issues while remaining within the realm of science. Through the implementation of SSI-based learning, students acquire scientific knowledge while simultaneously cultivating critical thinking abilities and problem-solving skills. This approach encourages students to recognize social issues, investigate possible solutions, and make evidence-based decisions, enabling them to actively participate at solving real-world problems.

Multiple prior studies have demonstrated that the utilization of SSI-based media in science education can enhance students' motivation to learn science, augment comprehension of the material, and bolster critical thinking abilities. Research by Heliawati et al., (2022) demonstrated that media significantly influenced student motivation, enhanced active engagement in learning, and fostered 21st-century skills, including critical thinking and autonomous learning. The utilization of this medium has been demonstrated to enhance student engagement and bolster their critical thinking skills, a key indicator of learning progress. This medium facilitates greater student engagement in learning, prompting them to explore, analyze, and comprehend scientific materials thoroughly, thereby enhancing their preparedness to address diverse challenges (Suryanti et al., 2021).

METHOD

This study employed a meta-analysis research design, a quantitative method intended to synthesize results from various primary studies. This technique analyzes and synthesizes data from multiple studies into a cohesive product, offering a deeper and more comprehensive understanding of the subject matter. A meta-analysis enables researchers to assess the consistency of prior research findings and to discern prevalent trends and deficiencies that necessitate further investigation in subsequent studies (Schroeder et al., 2007).

This meta-analysis employs the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) methodology, executed systematically in accordance with established protocols and stages. This study employs electronic instruments, including mobile phones, laptops, and internet connectivity through operator cards and Wi-Fi. These instruments were employed to gather materials in the form of scientific literature, specifically research journals pertinent to the subject of scientific literacy.

Literature searches were performed online using sources including Google Scholar, Scopus. The utilized keywords comprised: “Learning Media,” “SSI,” “Science Literacy,” and “Student Literacy Improvement.” The criteria for the journal article review analysis are as follows: a) Examination of learning media; b) Advancement of scientific literacy competencies; c) The sample must consist of students from elementary school, junior high school, high school, and college.

The data acquired from each study comprises findings published in research journals from 2018 to 2024.

The procedure of identifying eligible research studies for meta-analysis according to the PRISMA guidelines can be seen in figure 1.

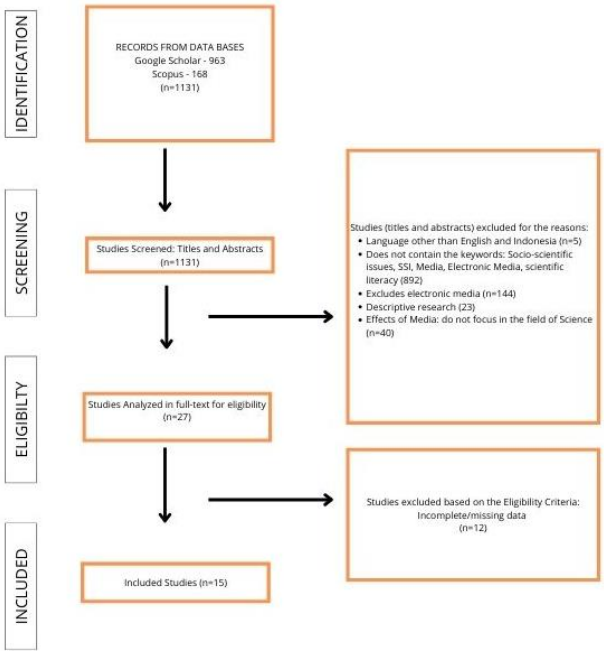

Figure 1. Research Studies Selection using PRISMA (Hak et al., 2016)

Data was collected through different processes, commencing with the formulation of a precise research question. A systematic literature search was subsequently performed by inputting keywords into the journal database. A screening and selection process was subsequently conducted on journals pertinent to the research topic. The qualitative findings were subsequently analyzed and synthesized, demonstrating effective management of the search process. Quality control was executed by meticulously evaluating the gathered research evidence to detect any bias. A conclusive report was generated subsequent to data extraction and research synthesis. All pertinent data concerning the utilization of SSI integrated media in relation to students' science literacy were gathered and conformed to the criteria established by the reviewers, offering a thorough overview of the efficacy of this method in science education.

RESULTS

This study selected 15 articles from national and international sources regarding the efficacy of digital learning media in enhancing students' science literacy. The data from these articles were subsequently summarized to ascertain the fundamental results of the research on learning media. Moreover, the acquired data has been reformulated in both qualitative and quantitative descriptive formats. The following are the outcomes of data analysis regarding the utilization of educational media

Table 1. Analysis results regarding the impact of learning media on enhancing students' scientific literacy

No	Journal's Code	Pre Test	Post Test	N-Gain	N-Gain %
1	GBIM-SSI	31	55	0,4	40%
2	SSI-WS	34,77	72,44	0,57	57%
3	EGIM-GZ	35,55	66,95	0,49	49%
4	ESS-SSI	30,62	63,34	0,47	47%
5	EDM-SHS	47,25	76,7	0,558294	55,82%
6	PMK-STB	53,13	69,38	0,7746	77%
7	PMP-PEL	51,34	86,74	0,75	75%
8	PMF-KS	34,14	81,58	0,7149	71.49%
9	DEM-EM	38,53	73,98	0,57	57%
10	PMF-LS	46,66667	86,2963	0,746914	74,70%
11	PVP-OM	47,25	76,7	0,558294	55,82%
12	EBM-MM	42	63,71	0,571316	57,13%
13	EVR-GA	45,39	85,56	0,73558	73,55%
14	EBM-MM	51	77,95	0,55	55%
15	VRG-BL	61,41	83,59	0,57476	57,47%

Table 1 indicates an increase in the pre-test and post-test scores, demonstrating a positive impact of utilizing diverse learning media on enhancing students' science literacy.

Table 2. Table of paired samples statistic.

Paired Sample Statistic					
		Mean	**N**	**Std. Deviation**	**Std. Error Mean**
Pair 1	**Pretest**	43.3367	15	9.05809	2.33879
	Posttest	74.6613	15	9.54043	2.46333

The "Paired Samples Statistics" table 2 presents a summary of the descriptive statistics for the two variables (Pre Test and Post Test) assessed on the identical sample of 15 articles.

Tabel 3. Table Paired Samples Correlations

		N	**Correlations**	**Sig.**
Pair 1	**Pretest & Posttest**	15	.602	.018

Table 3 presents the correlation between pretest and posttest scores for a sample of 15 individuals. The correlation coefficient between the pretest and posttest is 0.602, signifying a moderate positive correlation between the two assessments.

The paired sample t-test results indicated a significant enhancement in students' science literacy following the implementation of learning media. The table indicates that the mean difference between the pretest and posttest is -31.32. The statistical test reveals a t value of -14.606 with 14 degrees of freedom (df). The significance value (Sig. 2-tailed) is 0.000, which is beneath the significance threshold of 0.05.

Table 4. Paired Sample t-Test

		Mean	**Std. Deviation**	**Df**	**Sig. (2-tailed)**
Pair 1	**Pretest-Posttest**	-31.32467	8.30617	14	.000

DISCUSSION

According to Table 1, the Pre-Test scores, which span from 30.62 to 61.41, reveal a disparity in students' initial comprehension levels. Following the implementation of the learning media, the Post-Test scores exhibited a notable enhancement, ranging from 55 to 86.74. The N-Gain value, classified as moderate to high, attained a peak of 0.7746 (77%) in the PMK-STB journal code. This increase indicates that technology-based educational media focused on socio-scientific issues (SSI) can promote interactive learning, align with real-world contexts, and enhance comprehension of scientific principles.

Table 2 indicates that the mean score for the pretest was 43.3367, with a standard deviation of 9.05809, whereas the mean score for the posttest was 74.6613, with a standard deviation of 9.54043. The elevated mean on the post-test suggests a potential significant alteration between the two variables, possibly reflecting the impact of the administered treatment or intervention. The standard error of the mean for the pre-test was 2.33879, while for the post-test it was 2.46333. The standard error of the mean reflects the degree of uncertainty in estimating the population mean from the sample. A diminished standard error signifies a more precise estimation of the mean. The notable disparity between the pretest and posttest means suggests a beneficial impact of learning media on students' scientific literacy.

According to Table 3, the correlation coefficient between the pretest and posttest is 0.602, signifying a moderate positive correlation between the two assessments. This indicates a robust correlation between pretest and posttest scores; participants who achieve high scores on the pretest generally attain high scores on the posttest, and conversely. The significance value (Sig.) is 0.018, which is less than 0.05, indicating that this correlation is statistically significant.

Table 4 indicates the mean difference between the pretest and posttest, as indicated in the table, is -31.32. This signifies that the posttest scores were, on average, superior to the pretest, demonstrating an enhancement in science literacy skills following the educational intervention. The standard deviation of 8.31 reflects the variability in score differences among students, while the standard error of the mean of 2.14 signifies the precision of the mean estimate. The statistical test yielded a t value of -14.606 with 14 degrees of freedom (df). The significance value (Sig. 2-tailed) was 0.000, which is below the threshold of 0.05. The augmentation in scientific literacy, as evidenced by pretest and posttest scores, is statistically significant. The utilization of educational media significantly enhances students' scientific literacy. The 95% confidence interval for the mean difference is (-35.92, -26.72), confirming a significant reduction in the difference between pretest and posttest scores, which signifies an enhancement in science literacy.

This study aimed to assess the efficacy of digital learning media in enhancing students' science literacy. The analysis results indicated a significant enhancement in students' pretest and posttest scores, along with the beneficial impact of digital learning media on their science literacy skills.

From the meta-analysis results shown in Table 1, it can be seen that there is a significant increase between the pretest and posttest scores. This result shows that the application of various learning media, both digital-based, is able to improve students' science literacy. For example, the journal code **PMK-STB** showed an N-Gain improvement of 77%, which is one of the highest improvements among other journals. This indicates that the use of SSI-based learning media can stimulate more interactive and contextualized learning, and deepen students' understanding of scientific concepts.

The use of digital media in science learning allows students to interact with learning materials in a more dynamic and interesting way so that they understand the material better. This is in line

with Fujiyanto's opinion that one of the efforts in helping students to understand the abstract material is by using learning media that can concretize abstract concepts (Fujiyanto et al., 2016). Interactive multimedia has a dynamic display so that it has its own appeal for students to continue learning (Wahyudiani et al., 2020)(Najib et al., 2018). Scientific simulations, animations, and visualization of concepts that are difficult to understand become easier for students to accept and understand (Indah & Fadilah, 2024)(Cahyaningrum et al., 2022). This is in line with the theory of constructivism which emphasizes active learning, where students construct their own knowledge through experience and interaction with the outside world.

Table 2 displays descriptive statistics revealing that the mean pretest score was 43.34, while the posttest score increased to 74.66. This increase illustrates the substantial impact of employing learning media on improving students' science literacy. The increased average posttest score indicates that students with initially lower comprehension (pretest score) improved their science literacy skills after using the learning media. The diminished standard error of the mean in the posttest (2.46333) compared to the pretest (2.33879) indicates that the estimation of the average posttest score is more stable and accurate. This suggests that the use of digital learning media has a more equitable impact on students with varying abilities, leading to improved overall understanding.

Table 3 presents a correlation coefficient of 0.602 between the pretest and posttest. This signifies a moderate positive correlation between pretest and posttest scores. Students with elevated pretest scores generally achieve high posttest scores, and conversely. A p-value less than 0.05 ($p = 0.018$) signifies that this correlation is statistically significant, supporting the conclusion that a positive relationship exists between students' initial understanding and the improvement attained after utilizing the learning media.

The results of the paired sample t-test presented in Table 4 indicate a significant difference between the pretest and posttest scores. The substantial t-value (-14.606) with 14 degrees of freedom and a significance level ($p = 0.000$) signifies a highly significant difference between the pretest and posttest scores. The utilization of digital learning media and SSI significantly enhances students' science literacy. The 95% confidence interval value (-35.92, -26.72), which excludes zero, further substantiates this conclusion, signifying that the disparity between the pretest and posttest is substantial and not attributable to chance.

Electronic media plays an important role in Socio-Scientific Issues (SSI)-based learning by providing interactive tools that can dynamically convey contextual issues. The simulation, animation and visualization offered by electronic media make it easier for students to understand abstract concepts more concretely and interestingly (Wahyudiani et al., 2020). In addition, electronic media allows students to explore real problems independently, thus strengthening analytical skills and practicing evidence-based decision making. The integration of technology in SSI-based learning also makes it more relevant, improving students' science literacy, while motivating them to be more actively involved in solving complex social issues (Rohmaya et al., 2023).

The SSI approach connects science learning to the context of real social issues, such as climate change and pollution, that are relevant to students' daily lives (Sadler, 2011). This context not only increases students' motivation to learn, but also shows how the subject matter has a direct connection to their lives. In addition, SSI trains students to think critically, consider multiple perspectives, and make wise decisions based on scientific evidence (Anggi & Solihat, 2024). The analytical and reflective skills developed through this approach become an integral part of science

literacy, where students not only understand concepts, but are also able to apply them to solve real problems (Hestiana & Rosana, 2020).

Science learning that integrates SSI can develop students' science literacy skills while prioritizing the nature of science (Mudawamah, 2020). The SSI context has a major influence in training students to understand complex issues that are relevant to students' lives (Permanasari et al., 2021). This approach not only improves students' intellectual abilities, but also involves higher-order thinking skills, social abilities, and interdisciplinary understanding (Sari & Sutihat, 2022). By presenting a real context, SSI-based learning encourages students to think critically, solve problems, and make wise decisions on controversial social issues (Hestiana & Rosana, 2020). In SSI learning, students' arguments are required about an authentic problem that allows students to be active participants in making decisions democratically (Zeidler et al., 2019). Science literacy in this context includes the ability to integrate various perspectives to face real-world challenges, while training students to argue, make decisions, and develop moral awareness (Khasanah & Setiawan, 2022; Sirmayeni, 2023).

In addition, SSI-based learning also contributes to students' moral and social development (Khasanah & Setiawan, 2022; Sirmayeni, 2023). By raising dilemmatic and problematic issues, students are trained to consider ethical, moral, and social values in decision making (Zeidler et al., 2019). The context of SSI can enhance students' moral sensitivity and help them understand the social impact of their decisions. This is important for shaping a younger generation that has an awareness of social and ecological responsibility. SSI-based learning also equips students with the ability to become reflective and responsible citizens who are ready to face complex social challenges (Chowdhury et al., 2020). .

CONCLUSION

The meta-analysis of 15 articles indicates that the utilisation of SSI-based digital learning media significantly enhances students' science literacy. The substantial rise in pretest and posttest scores is evident, corroborated by the Paired Sample T-Test results indicating a significance value of 0.000, alongside the Effect Size findings demonstrating a considerable positive effect on the majority of the analysed journals. The rise in average pretest and posttest scores indicates that diverse learning media, particularly digital formats, enhance students' comprehension of scientific concepts. This aligns with constructivist theory, which posits that active learning via interactive media enhances students' comprehension and scientific literacy. The utilisation of SSI-based learning media enhances students' critical thinking by prompting them to evaluate the social and ethical ramifications of science, thereby reinforcing their scientific literacy

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