



Development of an e-worksheet based on a socio-scientific issue skincare issue reproductive system material to improve conceptual understanding and reflective thinking of Grade XI students

Nayomi Riski Wardani¹, Kartika Ratna Pertiwi^{1*}

¹Biology Education Study Program, Universitas Negeri Yogyakarta, Indonesia

E-mail: kartika.pertiwi@uny.ac.id

Abstract. This study aims to (1) assess the feasibility of developing an e-worksheet based on Socio-Scientific Issues (SSI) with skincare issues for reproductive system material, and (2) test its effectiveness in improving conceptual understanding and reflective thinking of Grade XI students. The study used a Research & Development (R&D) design with the ADDIE (Analysis, Design, Development, Implementation, Evaluation) model implemented at SMA Negeri 1 Pengasih. Subjects included material experts, media experts, learning experts, and 36 students selected by purposive sampling. Data collected through observation, interviews, validation questionnaires, and pretest–posttest tests were analyzed descriptively, qualitatively, and quantitatively. The results showed that an e-worksheet on SSI (skincare issues) was developed as an interactive, easy-to-understand, website-based learning medium, featuring relevant news articles, images, and videos. Expert validation showed high feasibility; students gave a positive response of 92%; and effectiveness testing showed an increase, with an n-gain score in the moderate category. In conclusion, the SSI-based e-worksheet on skincare issues is feasible to use and is quite effective in improving conceptual understanding and reflective thinking skills of Grade XI students. The implications of this study indicate that integrating popular contextual topics among adolescents, such as skincare, can serve as an effective alternative digital learning strategy to bridge abstract biological concepts with the realities of everyday life, while simultaneously encouraging critical reasoning and students' responsiveness to social science issues.

Keywords: *Conceptual understanding, E-worksheet, Reflective thinking, Reproductive system, Socio-scientific issues*

Received: 18 January 2026 Revised: 28 September 2026 Accepted: 28 September 2026 Published: 28 September 2026

INTRODUCTION

The development of information technology and the era of digital disruption have fundamentally changed the communication landscape and access to information in modern society. Increasingly widespread access to social media platforms such as Instagram and TikTok, as well as e-commerce platforms, has not only influenced social interaction patterns but also driven the rapid consumption of cosmetic and skincare products among teenagers (Trifunovski et al., 2025; Endris et al., 2026). This phenomenon has created new aesthetic standards, prompting teenagers to adopt various skincare products without adequate scientific literacy and understanding of their chemical compositions. The rise of aggressive digital marketing is often not balanced by transparent scientific information, potentially leading to widespread misinformation about the safety of personal care products used daily by the younger generation (Alblooshi, 2025).

This situation raises crucial socio-scientific issues (SSI), in which the use of unregistered skincare products or those containing high-risk active ingredients such as hydroquinone, phthalates, and endocrine-disrupting chemicals (EDC) can have adverse health effects (Djamzuri & Mulyana, 2024; Kalofiri et al., 2023). Physiologically, cumulative exposure to these chemical compounds can disrupt the hormonal system and the function of

human reproductive organs (Akbar et al., 2025; Street et al., 2018). The direct link between daily skincare consumption habits and reproductive health threats makes this topic a very real, urgent, and contextual learning context to be addressed in biology lessons at the secondary school level.

On the other hand, the 21st-century education sector faces significant challenges in ensuring effective learning and equipping students with the 4C skills (Critical Thinking, Creativity, Collaboration, Communication), a deep understanding of concepts, and higher-order thinking skills (Partnership for 21st Century Learning, 2019). However, international indicators such as the Program for International Student Assessment (PISA) consistently show that Indonesian students' scientific literacy and scientific reasoning skills remain relatively low (OECD, 2019). This ideal situation is not entirely in line with the reality on the ground, including at SMA Negeri 1 Pengasih, where biology instruction remains predominantly teacher-centered and relies on conventional methods. Learning that emphasizes memorizing textual material without connecting it to real-world phenomena results in low student engagement, analytical skills, and critical reflection (Fina & Mulyono, 2025).

To address this pedagogical gap, learning strategies are needed that connect biological concepts with relevant social, ethical, and cultural issues. The Socio-Scientific Issues (SSI) approach offers both a theoretical and practical solution by presenting scientific dilemmas that are ill-structured and controversial (Sadler, 2011; Zeidler & Sadler, 2023). Through SSI, students are not only required to understand biological concepts substantively but also encouraged to evaluate scientific evidence, consider ethical aspects, and engage in critical reasoning before making decisions (Chowdhury et al., 2020). This process of synthesis and deliberation based on real-life dilemmas is crucial for developing reflective thinking skills, namely, students' ability to critically review their experiences, assumptions, and scientific understanding to formulate rational conclusions (Kember et al., 2008).

Along with the shifting characteristics of students as digital natives, innovation in the development of information technology-based learning instruments is imperative. Electronic Student Worksheets (e-worksheets) offer the advantages of flexibility, interactivity, and accessibility compared to traditional print media (Sung et al., 2016). According to Multimedia Learning Theory, integrating multimodal elements such as current news articles, representative images, and interactive learning videos into e-worksheets can strengthen cognitive scaffolding and facilitate a more concrete understanding of concepts (Mayer, 2014). Observations and an initial needs survey at SMA Negeri 1 Pengasih also indicated that students demonstrated significantly higher enthusiasm and interest in learning when material was presented through responsive electronic media and connected to popular daily issues.

Based on the problem analysis, the urgency of health literacy, and the need for digital learning media in the field, there is an innovation gap that requires addressing by integrating cosmetic (skincare) issues into interactive biology learning media. To provide a concrete pedagogical solution, this research was conducted to develop and test the effectiveness of SSI-based digital learning media. Therefore, this R&D research is focused on "Development of Socio-Scientific Issue (SSI) Based e-worksheets on Skincare Issues on Reproductive System Material to Improve Conceptual Understanding and Reflective Thinking of Grade XI Students", which is expected to produce a tested learning instrument that not only facilitates mastery of biology material, but also fosters critical attitudes and reflective thinking in students towards science issues in everyday life.

METHOD

This research employed a Research and Development (R&D) approach to develop an e-worksheet product. The chosen development model was ADDIE (Analysis, Design, Development, Implementation, Evaluation) to ensure a systematic, theoretically grounded

instructional design process ready for testing and evaluation. The research was conducted at SMAN 1 Pengasih from January to August 2025, with stages including development, limited trials, expert validation, and formative revisions, following the ADDIE cycle.

The research subjects included validators (material, media, and learning experts/teachers) and students as product users. The student sample consisted of 36 11th-grade students (one class, XIB) at SMAN 1 Pengasih, selected through purposive sampling to participate in the limited trials, complete pretests and posttests, and respond to questionnaires.

Data collection instruments included classroom observations, structured interviews with teachers, and validation and response questionnaires (media/material expert/teacher validation sheets and student user questionnaires using Likert and Guttman scales). The main instruments included pretests and posttests consisting of multiple-choice questions and essays, designed to measure conceptual understanding and levels of reflective thinking, based on the indicators of Kember et al. (2008). Multiple-choice questions were scored binary (1/0), while essays were scored according to the level of reflectiveness (1–4). All instruments were validated by experts before use.

Data analysis was conducted using a mixed approach: (1) qualitative descriptive analysis for interview data and student needs (outlining field findings as a basis for development), (2) quantitative descriptive analysis for assessing the feasibility and practicality of the product (converting Likert scores 1–4 to percentages and feasibility categories), and (3) pretest–posttest effectiveness testing, including checking for normality using the Shapiro–Wilk test. If the data met parametric assumptions, parametric tests (e.g., paired t-test) were used; otherwise, nonparametric tests (e.g., Wilcoxon signed-rank) were used. Furthermore, to measure the extent of improvement in students' conceptual understanding and reflective thinking abilities, the N-Gain score is used with categories (high, medium, low) and the N-Gain percentage effectiveness criteria as determined. Table 2 shows the categorization criteria of expert assessment. Table 2 shows the N-Gain value criteria and their representation.

Table 1. Product validity criteria

Percentage (%)	Criteria
81–100	Very Eligible
61–80	Eligible
41–60	Moderate
21–40	Ineligible
0–20	Very Ineligible

Source: Rohmah & Bukhori (2020)

Table 2. N-gain score categories

Gain normality value	Criteria
$0,7 < g = 1$	High
$0,3 < g \leq 0.7$	Medium
$g < 0.3$	Low

Source: Permatasari et al. (2019)

RESULTS AND DISCUSSION

Results

The development of SSI-based e-worksheets on reproductive system material is guided by the ADDIE model and intended for grade XI phase F students. The e-worksheet is presented digitally using the Google Sites platform. The needs analysis stage is conducted through interviews with subject teachers, direct observations at school, and student needs questionnaires; further curriculum and material analyses are carried out through literature reviews. The design stage begins with an initial chart-based design, followed by the creation of a storyboard. The development stage is carried out through editing, which will first be

corrected with the supervising lecturer and then further developed based on expert validation and limited trials. The implementation stage is carried out through tests before and after using the e-worksheet (pretest-posttest) to then test its effectiveness. The evaluation stage is carried out by conducting evaluations at each stage. Furthermore, the product will be validated through expert assessment.

Expert assessment

The results of the assessment by material experts are shown in Table 3.

Table 3. Assessment results by material experts

No	Aspects	Total score	Max score	Index (%)	Interpretation
1.	Suitability of Content	21	24	87.5	Very Eligible
2.	Presentation of Material	19	20	95	Very Eligible
3.	Relevance of Material to the Issue	7	8	87.5	Very Eligible
4.	Language	11	12	91.6	Very Eligible
Total score					58
Maximum score					64
Index (%)					90.6
Interpretation					Very Eligible

The assessment by the material experts covered several indicators: content suitability, presentation, relevance to the issue, and language. The assessment by the material experts revealed that the media scored 87.5% for content suitability, 95% for presentation, 87.5% for relevance to the issue, and 91.6% for language. The overall assessment was categorized as very appropriate, with a total score of 90.6%. The product, validated by material experts, was adjusted per the guidelines and deemed suitable for testing with revisions. The results of the media experts' assessment are shown in Table 4.

Table 4. Assessment results by media experts

No	Aspects	Total score	Max score	Index (%)	Interpretation
1.	Design	20	20	96.4	Very Eligible
2.	Presentation	8	8	100	Very Eligible
3.	Ease of Use	16	16	100	Very Eligible
Total score					44
Maximum score					44
Index (%)					100
Interpretation					Very Eligible

The media expert's assessment covered several indicators: design, presentation, and ease of use. The expert assessment revealed that the media received a score of 96.4% for design, 100% for presentation, and 100% for ease of use. The overall assessment was categorized as very appropriate, with a total score of 100%. The product, validated by the media expert, was evaluated against the guidelines and deemed suitable for testing, with revisions.

The results of the biology teacher assessment are shown in Table 5. Based on Table 5, the e-worksheet was assessed by an 11th-grade biology teacher at SMA Negeri 1 Pengasih. The assessment results showed a 97.7% score for presentation and content appropriateness, 100% for language, and 100% for conceptual understanding and reflective thinking skills. These findings indicate that the e-worksheet is attractively presented, easy to access and understand, uses appropriate language, and systematically and educationally presents the reproductive system and skincare issues. Overall, the e-worksheet received a score of 98.5%, categorized as very appropriate, and was deemed suitable for testing with revisions as directed.

Table 5. Assessment by biology teacher

No	Aspects	Total score	Max score	Index (%)	Interpretation
1.	Appearance and Content Suitability	43	44	97.7	Very Eligible
2.	Language	8	8	100	Very Eligible
3.	Reflective thinking skills and conceptual understanding	16	16	100	Very Eligible
Total score					67
Maximum score					68
Index (%)					98.5
Interpretation					Very Eligible

The results of the student assessments are shown in Table 6.

Table 6. Assessment results by students

No	Aspects	Total score	Max score	Index (%)	Interpretation
1.	Appearance Suitability	781	864	90.4	Very Eligible
2.	Ease of Use	526	576	91.3	Very Eligible
3.	Usability	398	432	91.6	Very Eligible
4.	Language	273	288	94.8	Very Eligible
Total score					1978
Maximum score					2160
Index (%)					92 %
Interpretation					Very Eligible

The e-worksheet assessment was conducted using a questionnaire administered to 36 11th-grade students at SMA Negeri 1 Pengasih. The results showed a feasibility percentage of 92%, categorized as very feasible. The display aspect obtained a score of 90.4%, ease of use 91.3%, usability 91.6%, and language 94.8%, all of which fell within the very feasible category. These findings indicate that the e-worksheet has an attractive appearance, is easy to access and understand, is useful for practicing conceptual understanding and reflective thinking skills, and uses language that conforms to the rules. Based on these results, the product is declared suitable to continue to the limited trial stage.

Product trial results

The effectiveness of a Socio-Scientific Issues (SSI)-based e-worksheet addressing skincare topics was analyzed by comparing pretest and posttest results to measure improvements in students' conceptual understanding and reflective thinking skills. The multiple-choice and essay-based instruments yielded scores, which were analyzed using IBM SPSS 25 for Windows. Data analysis included a normality test and a Wilcoxon signed-rank test as prerequisites for calculating normalized gain (N-Gain). The analysis steps and results are presented below.

The results of the normality test are shown in Table 7.

Table 7. Results of the Shapiro-Wilk normality test

Data	Shapiro-wilk			Interpretation
	Statistic	df	Sig.	
Conceptual Understanding Pretest	0.809	36	0.000	Not Normally Distributed ($p < 0.05$)
Conceptual Understanding Posttest	0.803	36	0.000	Not Normally Distributed ($p < 0.05$)
Reflective Thinking Pretest	0.910	36	0.006	Not Normally Distributed ($p < 0.05$)
Reflective Thinking Posttest	0.905	36	0.005	Not Normally Distributed ($p < 0.05$)

The results of the pretest and posttest data normality tests for the conceptual understanding and reflective thinking variables showed significance values (Sig.) < 0.05 , with

values of 0.000 for conceptual understanding and 0.006 and 0.005 for reflective thinking. These findings indicate that the data were not normally distributed, so further analysis was conducted using a nonparametric statistical test, namely the Wilcoxon signed-rank test.

The results of the nonparametric test are shown in Table 8.

Table 8. Wilcoxon Signed-rank test results

<i>Ranks</i>							
Concept Understanding				Reflective Thinking			
	N	Mean Rank	Sum of Rank		N	Mean Rank	Sum of Rank
Negative Ranks	0	0.00	0.00	Negative Ranks	0	0.00	0.00
Positive Ranks	36	18.50	666.00	Positive Ranks	36	18.50	666.00
Ties	0			Ties	0		
Total	36			Total	36		
<i>Statistics</i>							
Concept Understanding				Reflective Thinking			
Z			-5.273	Z			-5.528
Sig.(2-tailed)			0.000	Sig.(2-tailed)			0.000
Interpretation				H0 is rejected and H1 is accepted			

The results of the ranks table show that all students experienced an increase in their scores for conceptual understanding and reflective thinking, as indicated by positive ranks = 36, negative ranks = 0, and ties = 0. This finding indicates that 100% of respondents experienced an increase from the pretest to the posttest.

The Wilcoxon test results showed Z values of -5.273 ($p = 0.000$) for conceptual understanding and -5.528 ($p = 0.000$) for reflective thinking. Since the p-value is <0.05 , H_0 is rejected, and H_1 is accepted, indicating a significant difference between the pretest and posttest scores for both variables. Thus, the use of SSI-based e-worksheets significantly improved students' conceptual understanding and reflective thinking skills.

The results of the N-Gain test for the pretest and posttest for conceptual understanding in the limited test are shown in Table 9. The average pretest and posttest scores are shown in Figure 1.

Table 9. N-Gain scores for pretest and posttest concept understanding

Description	Pretest	Posttest
Highest Score	70	90
Lowest Score	30	70
Average	45.56	79.17
N-Gain Score		0.602
N-Gain Percentage		60.2%
Category	Moderate	

The results of the N-Gain pretest and posttest for reflective thinking in the limited test are shown in Table 10. The average pretest and posttest scores are shown in Figure 2.

Table 10. Results of the reflective thinking analysis

Description	Pretest	Posttest
Highest Score	65	85
Lowest Score	25	60
Average	42.92	75.97
N-Gain Score		0.573
N-Gain Percentage		57.3%
Category	Moderate	

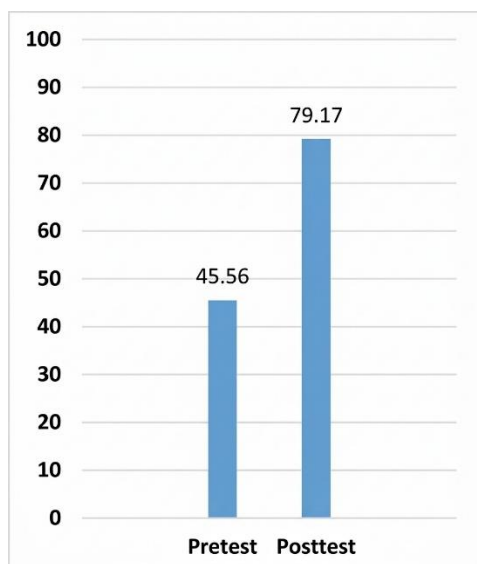


Figure 1. Average Pretest and Posttest Scores for Concept Understanding

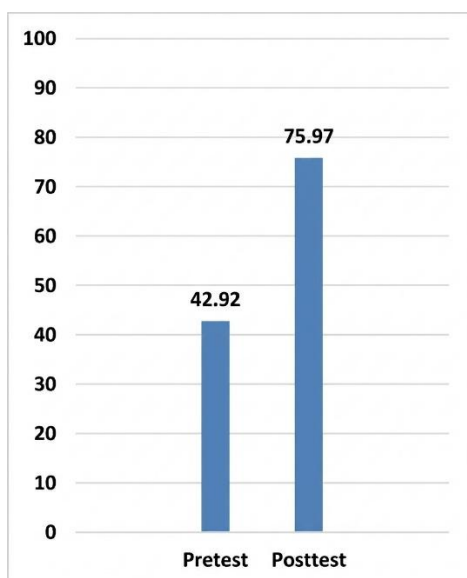


Figure 2. Average Pretest and Posttest Concept Understanding Scores

Based on the N-Gain analysis, the average conceptual understanding score increased from 45.56 (pretest) to 79.17 (posttest), with an N-Gain of 0.602, which is categorized as moderate (quite effective). Meanwhile, reflective thinking skills increased from an average of 42.92 to 75.97, with an N-Gain of 0.573, also categorized as moderate. The difference in improvement between the pretest and posttest for both variables is clearly visible in the N-Gain results diagram.

Discussion

A Socio-Scientific Issue (SSI)-based e-worksheet on the reproductive system was developed by using skincare use as a learning context relevant to students' lives. The e-worksheet is systematically structured, from the introduction of the issue to reflection on biological concepts, facilitating independent learning with a clear flow. Using skincare as a learning trigger allows students to analyze the relationship between chemicals in skincare products and the hormonal system and reproductive function, enabling them to understand biological concepts in context and practice.

A key characteristic of this e-worksheet is its interactive, web-based format, accessible on mobile devices and computers. This flexibility of access supports independent learning and is relevant to 21st-century learning needs. The use of multimedia such as text, images, videos, and supporting articles helps visualize abstract concepts and enriches students' learning experiences, in line with findings that digital e-worksheets can increase learning effectiveness and ease of access (Cahyani & Pertiwi, 2024; Lestari & Rakhmawati, 2024).

Validation results from material experts indicated that the e-worksheet was categorized as very suitable in terms of content, presentation, and language. The material was deemed appropriate for the learning objectives, students' cognitive level, and relevant to the socio-scientific issues raised. The systematic presentation and communicative language supported conceptual understanding, as research has shown that digital teaching materials with clear and simple language help students better grasp concepts (Anggrayni et al., 2024; Endris et al., 2026).

Assessments by media experts and biology teachers also confirmed the e-worksheet's suitability in terms of design, ease of use, and usability. The simple interface, clear navigation, and coherent user guide made it easy for students to access each section of the e-worksheet. From the perspective of Vygotsky's scaffolding theory, e-worksheets serve as learning aids that help students complete tasks independently and actively, thereby encouraging a shift from passive to more constructive learning (Aulia et al., 2022; Pamungkas et al., 2020).

Student responses were categorized as very satisfactory across all assessment aspects, including appearance, ease of use, usability, and language. Students considered the e-worksheet engaging, easy to understand, and useful in developing conceptual understanding and reflective thinking skills. These findings align with e-worksheet quality criteria, which emphasize the importance of positive student responses and the media's ability to develop targeted skills through the learning syntax used (Pristiwanti et al., 2024).

The effectiveness of the e-worksheet was analyzed through a one-group pretest-posttest trial. Wilcoxon test results showed a significant increase in students' conceptual understanding and reflective thinking skills after using the SSI-based e-worksheet. All students experienced an increase in their scores, with the N-Gain result being in the moderate category, indicating that the e-worksheet was quite effective in improving both skills. This improvement indicates that SSI-based learning can encourage deeper cognitive engagement and reflection among students.

The effectiveness of this e-worksheet is inseparable from the characteristics of the SSI approach, which requires students to analyze real-world issues, evaluate scientific evidence, and consider the social implications of a problem. This process encourages the development of scientific literacy, scientific argumentation, and reflective thinking skills. These findings are consistent with research that suggests SSI-based learning plays a crucial role in developing students' scientific literacy, critical thinking, and argumentation skills (Zeidler & Nichols, 2009; Ke et al., 2021; Sari et al., 2024).

Furthermore, the integration of multimedia and interactive activities in the e-worksheet supports various student learning styles and increases motivation and engagement. The website-based platform allows students to review and explore the material independently, thereby enhancing conceptual understanding and reflection. This finding is in line with studies reporting that the use of e-worksheets and digital e-worksheets contributes positively to digital literacy, conceptual understanding, and student learning engagement (Agisni et al., 2023; Distrik et al., 2024; Sinusi et al., 2022).

CONCLUSION

Based on the results of the development research, an SSI-based e-worksheet on the reproductive system material has been produced as a biology learning medium developed using

the ADDIE model. The results of the feasibility assessment by material experts, media experts, teachers, and students indicate that the developed e-worksheet is in the very feasible category. In addition, the trial results indicate that the e-worksheet is significantly effective ($p < 0.05$; Wilcoxon signed-rank test) in improving students' conceptual understanding and reflective thinking skills, with N-Gain values of 0.602 and 0.573, respectively. These findings suggest that integrating contextual socio-scientific issues, such as skincare safety, into digital learning media can bridge abstract biological concepts and everyday realities while fostering students' critical thinking. As a follow-up, further research is recommended to test the effectiveness of this e-worksheet on a broader, more heterogeneous sample, measure its impact on other 21st-century skills variables such as scientific decision-making, and explore emerging popular SSI issues across different biology topics.

REFERENCES

- Alblooshi, S. (2025). The impact of perfumes and cosmetic products on human health: a narrative review. *Frontiers in Toxicology*, 7, 1648075. <https://doi.org/10.3389/ftox.2025.1646075>
- Aulia, S., Wulandari, A. Y. R., Ahied, M., Munawaroh, F., & Rosidi, I. (2022). Uji Kelayakan Media Pembelajaran Interaktif Berbasis Android Menggunakan Articulate Storyline 3. *Natural Science Education Research*, 5(2), 40–59. <https://doi.org/10.21107/nser.v5i2.11854>
- Agisni, A., Novari, D., Leander, G., Prawirawan, B. U., & Pohan, A. H. (2023). The effectiveness of multimedia learning: A study on student learning. *Priviet Social Sciences Journal*, 3(7), 9–11. <https://doi.org/10.55942/pssj.v3i7.215>
- Akbar, A., Patandean, D., Nasrullah, I. K. D. S., & Furqan, M. (2025). Edukasi Penggunaan Skincare dan Kosmetik yang Aman. *Idea Pengabdian Masyarakat*, 5(02), 182–187. <https://doi.org/10.47200/JNAJPM.V5I2.182>
- Anggrayni, M., Darniyanti, Y., & Amal, I. (2024). Pengembangan Elektronik Lembar Kerja Peserta Didik (E-LKPD) Mata Pelajaran IPAS di Kelas IV SDN 07 Sitiung. *INNOVATIVE: Journal of Social Science Research*, 4(3), 17302–17324. <https://j-innovative.org/index.php/Innovative/article/view/12313>
- Cahyani, D. N., & Pertiwi, K. R. (2024). Pengembangan E-Lkpd Berbasis Pbl Materi Hormon Reproduksi Untuk Meningkatkan Literasi Kesehatan Reproduksi. *Jurnal Edukasi Biologi*, 10(2), 191–203. <https://doi.org/10.21831/edubio.v10i2.21810>
- Chowdhury, T. B. M., Holbrook, J., & Rannikmäe, M. (2020). Socioscientific issues within science education and their role in promoting desired citizenry. *Science Education International*, 31(2), 203–208. <https://doi.org/10.33828/sei.v31.i2.10>
- Distrik, I. W., Ertikanto, C., Purwati, Y. S., Saregar, A., & Ab Rahman, N. F. (2024). Digital Problem-Based E-worksheet With 3D Pageflip: An Effort To Address Concept Understanding Problems And Enhance Digital Literacy Skills. *Jurnal Pendidikan IPA Indonesia*, 13(1), 116–127. <https://doi.org/10.15294/jpii.v13i1.48604>
- Djamzuri, M. I., & Mulyana, A. P. (2024). Cancel Culture di Era Media Baru: Analisis Komunikasi Atas Implikasi Sosial dalam Kasus Overclaim Skincare. *Jurnal Nuansa Akademik: Jurnal Pembangunan Masyarakat*, 9(2), 523–534, <https://doi.org/10.47200/JNAJPM.V9I2.523>
- Endris, W. M., Ginanjar, G., & Rayhan, M. (2026). Pengembangan E-Lkpd Biologi Berbasis Model PEAS Terintegrasi Learning Management System. *EDUTECH: Jurnal Inovasi Pendidikan Berbantuan Teknologi*, 6(2), 372–383. <https://doi.org/10.51878/edutech.v6i2.9775>
- Fina, M. & Mulyono, Y. (2025). Efektivitas Pembelajaran Berbasis Masalah (*Problem-Based Learning*) Dalam Meningkatkan Pemahaman Konsep Biologi: Sebuah *Systematic*

- Review Dan Meta-Analisis. *Jurnal Metabio*, 7(1), 59–65.
<https://doi.org/10.36985/v0t4d059>
- Kalofiri, P., Biskanaki, F., Kefala, V., Tertipi, N., Sfyri, E., & Rallis, E. (2023). Endocrine Disruptors in Cosmetic Products and the Regulatory Framework: Public Health Implications. *Cosmetics*, 10(6), 160. <https://doi.org/10.3390/cosmetics10060160>
- 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 & Education*, 30(3), 589–607. <https://doi.org/10.1007/s11191-021-00206-1>
- Kember, D., McKay, J., Sinclair, K., & Wong, F. K. Y. (2008). A four-category scheme for coding and assessing the level of reflection in written work. *Assessment & evaluation in higher education*, 33(4), 369–379. <https://doi.org/10.1080/02602930701293355>
- Lestari, I., & Rakhmawati, A. (2024). Pengembangan lkpdp berbasis project-based learning untuk meningkatkan keterampilan kolaborasi siswa pada materi bioteknologi. *Jurnal Edukasi Biologi*, 10(2), 177–190. <http://dx.doi.org/10.21831/edubio.v10i2.19644>
- Mayer, R. E. (2014). *The Cambridge Handbook of Multimedia Learning* (2nd ed.). Cambridge University Press. <https://doi.org/10.1017/CBO9781139547369>
- OECD. (2019). *PISA 2018 Results (Volume I): What Students Know and Can Do*. OECD Publishing. <https://doi.org/10.1787/5f07c754-en>
- Pamungkas, M. D., Santoso, E., Rochmad, R., & Isnarto, I. (2020). Pendekatan saintifik dalam perspektif teori belajar Vygotsky. *Jurnal Didactical Mathematics*, 2(3), 109–114. <https://jurnal.unma.ac.id/index.php/dm/article/view/2525>
- Partnership for 21st Century Learning. (2019). Framework for 21st Century Learning. Battelle for Kids. Retrieved from <https://www.battelleforkids.org/>
- Permatasari, I., Ramdani, A., & Syukur, A. (2019). Pengembangan bahan ajar ipa berbasis inkuiri terintegrasi sets (science, Environment, Technology, and Society) pada materi sistem reproduksi manusia. *Jurnal Pijar Mipa*, 14(2), 74–78. <https://doi.org/10.29303/jpm.v14i2.1256>
- Pristiwanti, D., Hendrayana, A., & Nulhakin, L. (2024). Pengembangan E-LKPD Berbasis Kearifan Lokal Motif Batik Kota Serang dalam Meningkatkan Kemampuan Berpikir Kritis Peserta Didik Sekolah Dasar. *Ideguru: Jurnal Karya Ilmiah Guru*, 9(3), 1850-1856. <https://doi.org/10.51169/ideguru.v9i3.1352>
- Rohmah, F. N., & Bukhori, I. (2020). Development of interactive learning media for Android-based correspondence subjects using Articulate Storyline 3. *Economic and Education Journal (Ecoducation)*, 2(2), 169–182. <https://doi.org/10.33503/ecoducation.v2i2.892>
- Sadler, T. D. (Ed.). (2011). *Socio-scientific Issues in the Classroom: Teaching, Learning and Research*. Springer Science & Business Media. <https://doi.org/10.1007/978-94-007-1159-4>
- Sari, D. R., Saputro, S., & Sajidan, S. (2024). A Systematic Review on Integrating SSI into Science Education: Its Impact on 21st Century Skills (2014-2024). *Educational Studies and Research Journal*, 2(1), 1–14. <https://doi.org/10.60036/sa6n0870>
- Sinusi, N. S., Ibrohim, I., & Rahayu, S. E. (2022). Enhancing students' reflective thinking skills through Problem-Oriented Project-Based Learning (POPBL) with PEKERTI e-worksheet. *JPBI (Jurnal Pendidikan Biologi Indonesia)*, 10(3), 1107–1117. <https://doi.org/10.22219/jpbi.v10i3.36082>
- Street, M. E., Angelini, S., Bernasconi, S., Burgio, E., Cassio, A., Catellani, C., ... & Poluji, A. (2018). Endocrine disrupting chemicals: effects on human fertility and pregnancy outcome. *International Journal of Molecular Sciences*, 19(6), 1648. <https://doi.org/10.3390/ijms21041430>

- Sung, Y. T., Chang, K. E., & Liu, T. C. (2016). The effects of integrating mobile devices with teaching and learning on students' learning performance: A meta-analysis. *Computers & Education*, 94, 252–275. <https://doi.org/10.1016/j.compedu.2015.11.008>
- Trifunovski, A., Rotondi, N. K., Abbass-Dick, J., & Barakat, C. (2025). Analysis of Women's Knowledge, Health Risk Perceptions, Beliefs and Avoidance Behaviour in Relation to Endocrine-Disrupting Chemicals in Personal Care and Household Products. *Toxics*, 13(5), 414. <https://doi.org/10.3390/toxics13050414>
- Zeidler, D. L., & Nichols, B. H. (2009). Socioscientific issues: Theory and practice. *Journal of Elementary Science Education*, 21(2), 49–58. <https://doi.org/10.1007/BF03173684>
- Zeidler, D. L., & Sadler, T. D. (2023). Exploring and expanding the frontiers of socioscientific issues. In N. G. Lederman, D. L. Zeidler, & J. S. Lederman (Eds.), *Handbook of Research on Science Education* (1 ed., pp. 899–929). Routledge. <https://doi.org/10.4324/9780367855758>