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Teachers' and Students' Feedback on Sociocultural Interactive Digital Modules for Science Literacy and Problem-Solving: A Transformative Learning Approach

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ABSTRACT

Purpose of the study: This article examines the practicality of sociocultural-based interactive digital modules in improving students' science literacy and problem-solving skills by integrating a transformative learning approach.

Methodology: This descriptive research analyzes students' and teachers' responses to the developed interactive digital module. The study was conducted in junior high schools in Merauke Regency and Boven Digoel Regency, South Papua Province, totaling six schools. Data were collected through responses from 6 science teachers and 60 students involved in learning science with the module.

Main Findings: The results showed that this module is efficient for use in science learning, according to the responses from teachers and students. Feedback from teachers and students indicated that this module is efficient to use in science learning, as seen from the average total percentage given by teachers of 95% in the efficient category and provided by students of 95.53% in the efficient category. Through this article, the developed interactive digital module is feasible to use in science learning to improve science literacy and problem solving skills of junior high school students.

Novelty/Originality of this study: The module is designed with an approach that combines Papuan local wisdom values and transformative learning principles. This approach is rarely implemented simultaneously in the context of science learning to improve students' understanding of science. In addition, the interactive digital module not only focuses on understanding science materials but also connects them with local wisdom to increase the relevance of learning to students' daily lives.

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1. INTRODUCTION

Education is the process of maturing students so that they can develop their talents, potential and skills in living life [1]. 21st century science education not only emphasizes mastery of scientific concepts, but also students' ability to apply knowledge in real situations through problem-solving skills. Effective science learning should prepare students to think critically and creatively in the face of global challenges, in accordance with the objectives of the Program for International Student Assessment (PISA), which assesses science literacy and

problem-solving skills among students worldwide [2]. The effectiveness of learning will show the quality of the learning process that takes place [3]. Quality learning can improve students' problem solving and science literacy skills.

Problem solving skills are a form of higher-order thinking skills that must be provided to students. This skill is very important to train students because today students face life in an increasingly complex world [4]. The ability to read, analyze, and logic will help students solve problems effectively [5]. Problem solving skills can be developed through learning that involves active student participation [6], [7]. In an effort to improve students' problem solving skills, teaching materials are needed that can support the learning process such as modules, worksheet, package books, electronic books and others.

Indonesian students' literacy is currently still low, as seen from the 2018 PISA score which shows the average literacy of Indonesian students is only 371, far below the global average of 500 [8]. Therefore, it needs serious attention from all components of education to improve the literacy skills of students in Indonesia, including in science literacy. Science literacy is the ability to use science knowledge to identify questions, explain scientific phenomena that occur using contextual facts [9]. Science literacy is the ability to use scientific data and evidence to evaluate the quality of scientific information and argumentation [10]. Science literacy skills are very important to encourage science to provide better benefits in science learning [11]. In science learning, students are expected to have skills and be able to apply them to everyday life [12].

One approach that can improve science literacy is through the application of sociocultural-based interactive digital modules. Innovative digital technology learning must be responsive to local needs and educational structures [13]. The integration of technology in education has changed the traditional learning environment and opened up new opportunities to improve student engagement and learning outcomes. Today's world demands more efficient learning and involves active student participation with the utilization of technology [14]. The shift towards technology-based education requires the integration of interactive learning media to improve the effectiveness and efficiency of education in the digital era [15]. The use of digital technology can help students understand learning materials that cannot be done by conventional media [16]. The use of digital technology in learning has been proven to improve access and quality of learning [17]. One important innovation is the use of interactive digital modules designed to support the development of science literacy and problem solving skills. The use of digital modules is essential in improving students' critical thinking skills [18] [19]. This transition to digital learning methods serves to prepare students for the challenges of the modern world, where technology plays an important role in shaping their learning experience.

In the context of transformational learning, digital modules can be an effective tool to promote deeper understanding by encouraging students to critically reflect on their learning experiences and apply their knowledge to real-world problems. The application of digital science modules will help students understand concepts more thoroughly through engaging and relevant exercises [21]-[22]. One of the main challenges is how to effectively utilize interactive learning media to improve students' understanding in science lessons [23]. Therefore, this research focuses on the implementation of socio-cultural-based interactive digital modules in science education, which is in line with the PISA framework that emphasizes problem solving and the application of scientific knowledge in complex contexts [2].

Sociocultural theory, developed by Vygotsky [24], emphasizes the importance of social and cultural context in learning. The integration of local cultural values in this module also has the potential to increase students' sense of pride and appreciation of their cultural heritage [25]. In this context, interactive digital modules that integrate social and cultural elements can enhance students' understanding of science concepts in a more relevant and applicable way. In addition, transformative learning, which focuses on deep changes in the way students think, can strengthen their problem-solving skills and science literacy.

Recent research shows the importance of interactive digital learning environments in science education. Digital tools, when used effectively, can engage students in critical thinking, promote collaboration and improve problem-solving skills [26]. Research shows that the integration of technology in learning can create a more interactive, engaging and effective learning experience for students, improving their literacy and understanding of the subject matter [27], [28]. A socio-cultural approach to learning, which emphasizes the role of context and social interaction in knowledge construction [24]. This approach also enhances student engagement and facilitates deeper understanding in science education. In particular, modules that integrate cultural relevance in the learning process can increase students' motivation and their recall of scientific concepts.

In addition, transformational learning theory states that the most meaningful learning occurs when it causes significant changes in learners' perspectives and ways of thinking [29]. Transformative learning means a learning model developed from a transformative point of view [30]. By applying transformational learning principles to digital modules, students are encouraged to reflect on their prior knowledge, question existing assumptions, and engage in problem-solving tasks that require the application of scientific principles in a new context [31]. This study aims to explore how a sociocultural-based interactive digital module, which integrates transformative learning principles, to improve students' science literacy and problem-solving skills, as well as to obtain feedback from teachers and students on the effectiveness of this module.

2. RESEARCH METHOD

This research is a descriptive study to analyze student and teacher responses to the interactive digital module that has been developed. The responses of students and teachers will show the practicality of the interactive digital module that has been developed. The research was conducted in junior high schools in Merauke Regency and Boven Digoel Regency, South Papua Province, totaling 6 schools. Data were collected through responses from 6 science teachers and 60 students involved in learning science with the module. The module is designed to present science materials in a social and cultural context relevant to students' daily lives, with the aim of improving their understanding of scientific concepts as well as their ability to solve problems.

Data were collected through questionnaires given to students and teachers involved in the application of sociocultural-based interactive digital modules in science classes. The questionnaire was prepared with answers using a Likert scale, namely strongly agree (SS), agree (S), disagree (TS), and strongly disagree. (STS). The data were analyzed using descriptive statistics to describe the perceptions of students and teachers regarding the module. In the data analysis process, each question item will calculate the average of each student and teacher answer, then calculate the percentage of answers from each student and teacher, and calculate the total percentage of student and teacher answers. Students' and teachers' responses to the module were analyzed to evaluate its effectiveness in achieving the predetermined learning objectives and to determine the practicality of the digital module. The categorization of practicality results from the modification [32], can be seen in the following table 1.

Table 1. Categorization of Practicality

Percentage	Kriteria
$80\% < X \leq 100\%$	Very Practical
$60\% < X \leq 80\%$	Practical
$40\% < X \leq 60\%$	Moderately Practical
$20\% < X \leq 40\%$	Less Practical
$0\% < X \leq 20\%$	Not Practical

3. RESULTS AND DICUSSION

This research has been conducted in junior high schools in Merauke Regency and Boven Digoel Regency, South Papua Province, totaling 6 schools. The research involved teachers and students from the six schools with 6 science teachers and 60 students who became respondents, where these respondents were involved in learning science using the module. The results of the study are described as follows.

3.1. Teachers' responses to the interactive digital modules

Table 2. Teachers' responses

No.	Indicator	Score						
		A	B	C	D	E	F	Average
1	Alignment of content with Papua Local Wisdom	4	3	4	4	4	4	3.83
2	Content alignment with junior high school level	4	4	4	4	3	4	3.83
3	IDM alignment with student characteristics	4	4	4	4	4	4	4
4	Content alignment with teaching needs	4	4	4	3	4	4	3.83
5	Clear, attractive, and understandable images in IDM	4	3	4	4	4	4	3.83
6	Readable text	4	4	4	4	4	4	4
7	Ease of use of IDM	4	4	4	4	4	4	4
8	Local wisdom-based IDM makes the content easier to understand	4	4	4	4	4	4	4
9	Clarity of language used in IDM	3	2	4	3	3	3	3
10	Science literacy questions are easy to understand	4	3	3	4	3	4	3.5
11	Video learning via barcode enhances concept understanding	4	4	4	4	4	4	4
12	IDM attracts students' interest in reading	4	4	4	4	4	4	4
13	IDM includes questions that test concept comprehension	4	4	4	4	4	4	4

No.	Indicator	Score						
		A	B	C	D	E	F	Average
14	IDM includes questions that test problem-solving skills	3	3	4	3	3	3	3.17
15	IDM can be used for independent learning	4	4	4	4	4	4	4
Total Score		58	54	59	57	56	58	57
Maximum Score		60	60	60	60	60	60	60
Percentage		96.67	90	98.3	95	93.33	96.7	95

Based on the survey data, teachers provided positive responses to the Interactive Digital Module (IDM) based on local wisdom for improving science literacy and problem-solving skills. The average score ranges between 3.17 and 4, with an overall average percentage of 95%, which falls into the Highly Practical category. Several standout indicators, such as content alignment with teaching needs and student characteristics, received an average score of 3.83. This demonstrates that the IDM has been adapted to diverse teaching conditions, including the characteristics of the students. A study by Solihati [33] affirms that learning materials incorporating local wisdom can increase students' motivation and connection to their learning environment.

Teachers also rated text readability highly (score of 4) and found the images in the IDM to be clear and understandable (score of 3.83). This aligns with the findings of Indah dan Fadillah [34], which emphasize that visual and textual quality in digital modules significantly impact students' understanding of science concepts and literacy. The indicators for ease of use and the inclusion of concept-testing questions achieved an average score of 4, indicating that teachers find the IDM practical and functional for teaching. According to Kholidah dan Savitri [35], engaging students in problem-solving tasks through digital modules fosters higher problem-solving skills.

However, the indicator *"IDM attracts students' interest in reading"* scored slightly lower (3.17). While generally practical, this suggests that further innovation in module design is needed to make it more engaging. Research by Munawir et al [36] highlights the importance of interactivity in digital modules to enhance student engagement and motivation in technology-based learning. The indicator on language clarity received an average score of 3.5, while video learning achieved the highest rating (4), demonstrating the effectiveness of multimedia elements in supporting content delivery. According to Hartati dan Siregar [37], integrating video learning enhances conceptual understanding in science education.

These findings indicate that the interactive module based on local wisdom is highly effective in supporting science education, consistent with the principles of transformative learning, which emphasize local context. Images, text, and videos play a crucial role in facilitating understanding, while special attention is needed to improve interactivity to further stimulate students' interest in learning.

3.2. Students' responses to the interactive digital modules

Table 3. Student's responses

No	Indikator	Score						
		A	B	C	D	E	F	Average
1	Alignment of content with Papua Local Wisdom	3.7	3.5	3.7	3.5	3.4	3.4	3.53
2	Content alignment with junior high school level	3.9	3.8	4	3.8	3.6	3.5	3.77
3	IDM alignment with student characteristics	3.9	4	3.9	4	4	4	3.97
4	Content alignment with teaching needs	4	4	4	3.9	3.9	3.9	3.95
5	Clear, attractive, and understandable images in IDM	3.7	3.7	4	3.7	3.9	3.9	3.82
6	Readable text	3.9	3.9	3.9	3.9	4	3.9	3.92
7	Ease of use of IDM	4	3.9	4	3.9	3.9	4	3.95
8	Local wisdom-based IDM makes the content easier to understand	3.3	3.5	3.6	3.7	3.6	3.7	3.57
9	Clarity of language used in IDM	3.9	3.9	4	4	4	4	3.97
10	Science literacy questions are easy to understand	3.2	3.7	3.8	3.6	3.7	3.7	3.62
11	Video learning via barcode enhances concept understanding	3.5	3.6	3.8	3.4	3.6	3	3.48

No	Indikator	Score						
		A	B	C	D	E	F	Average
12	IDM attracts students' interest in reading	4	4	3.8	4	3.9	3.8	3.92
13	IDM includes questions that test concept comprehension	3.9	3.8	3.9	3.8	4	3.9	3.88
14	IDM includes questions that test problem-solving skills	4	4	4	4	3.9	4	3.98
15	IDM can be used for independent learning	4	4	4	4	4	4	4
Total Score		58	56.9	57.3	58.4	57.2	57.4	57.3
Maximum Score		60	60	60	60	60	60	60
Percentage		96.67	94.83	95.5	97.33	95.33	95.7	95.5

Based on the results of the student response questionnaire, it can be concluded that the local wisdom-based interactive digital module received very positive evaluations from students. The average score for each indicator ranged from 3.53 to 4, with an overall average percentage of 95.5%, placing it in the Highly Practical category.

The first indicator, “The material in the IDM is easy to understand” obtained an average of 3.53, while “The lessons linked to local wisdom make it easy for me to understand” reached 3.76. This shows the effectiveness of local wisdom integration in facilitating students' understanding of the material. Research by Putri et al, confirmed that the application of local wisdom-based learning in learning tools can improve students’ knowledge in learning learning materials, improve and develop students’ caring attitudes in preserving the environment, and can develop students’ skills through problem-solving-based learning [38]. Responses to the indicator “The images in the IDM are interesting and clear” had an average score of 3.95, while the indicator “The color display of the IDM is interesting so I am interested in learning” reached 3.96. This shows that attractive visual elements play a significant role in maintaining student engagement. Widiastari and Puspita’s research stated that attractive visualizations in digital modules increase student learning motivation and help better concept understanding [39].

The indicators “*IDM is easy to use for learning*” and “*IDM can be used offline without incurring costs*” achieved average scores of 3.91 and 3.95, respectively. This highlights the advantages of IDM in terms of practicality and accessibility. According to Tandikombong et al [40], ease of access, particularly offline use, greatly benefits students in areas with limited internet access. The indicator “*IDM motivates me to discuss with peers and ask questions to the teacher*” scored 3.61, slightly lower compared to other indicators. This suggests that while IDM motivates students, its collaborative aspect can still be improved. Usmeldi et al. [41] emphasized that interactive modules need to be designed to encourage active discussion and group-based learning.

The indicator “*The content in IDM helps me understand the application of science concepts in daily life*” received a score of 3.91. This underscores that students perceive the relevance of science material to their daily lives. Irsan [42] support this finding, stating that applying science in real-life contexts improves science literacy and problem-solving skills. The results of this study demonstrate that local wisdom-based IDM is highly practical for science learning and effective in enhancing conceptual understanding, motivation, and student engagement. However, the interactivity of the module needs to be improved to encourage more discussion and collaboration among students.

Based on the results of the teacher and student response questionnaires regarding the local wisdom-based Interactive Digital Module (IDM), the following findings are observed: 1) Practicality of IDM, Local wisdom-based IDM was rated as highly practical by both teachers and students, with average percentages reaching 95% (teachers) and 95.53% (students). This indicates that the module meets the criteria of practicality in supporting science learning; 2) Relevance of Content with Local Wisdom, Teachers and students agree that the integration of local wisdom in IDM helps them better understand science content. This proves that a context-based approach is effective in connecting science concepts to everyday life, thereby improving students' science literacy; 3) Visual Design and Readability of the Module, Visual elements, such as images and color schemes, were rated as attractive and helpful for understanding concepts. A well-designed visual component in IDM plays a crucial role in maintaining students' motivation and engagement during learning; 4) Ease of Use and Accessibility, The IDM was rated as easy to use by both teachers and students. The ability of the module to be used offline is an added advantage, especially in regions with limited technological access; 5) Improvement in Conceptual Understanding and Application, The IDM helps students understand the application of science concepts in daily life, supporting the transformative learning approach. Students find the content in IDM relevant and applicable to solving real-life problems; 6) Collaboration and Discussion Aspects, While IDM was rated as practical, aspects related to motivation for discussion and collaboration still need improvement. This indicates

that the module design can be further developed to encourage interactive, discussion-based learning among students.

The results of this study provide evidence that local wisdom-based IDM is not only practical but also effective in improving students' science literacy and problem-solving skills. However, enhancing the module's interactivity through collaborative features is necessary to further promote student engagement in group learning.

4. CONCLUSION

This study shows that sociocultural-based interactive digital modules that integrate transformative learning principles can improve students' science literacy and problem-solving skills. Feedback from teachers and students showed that this module is very practical to use in science learning, seen from the average total percentage given by teachers of 95% in the very practical category and that given by students of 95.53% in the very practical category. In addition, this module also facilitates better science literacy and problem-solving skills and creates changes in the way students understand and apply science knowledge.

From the results of this study, it is recommended that this sociocultural-based interactive digital module be applied more widely at various levels of education to improve students' science literacy and problem-solving skills. Further research can be conducted to explore the effect of this module on other aspects of science education, such as collaboration and communication skills.

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REFERENCES

[1] E. Rachmawati, B. Kurniawan, H. W. Arkew, and A. Singh, "Development of Web-Based geography learning media for high school students," *J. Eval. Educ.*, vol. 5, no. 1, pp. 34–41, 2024, doi: 10.37251/jee.v5i1.824.

[2] OECD, *PISA 2018 Global Competence*, Paris, 2018.

[3] J. J. Pongkendek, J. Y. Parlindungan, and D. N. Marpaung, "Effectiveness of the application of team games tournament cooperative learning model (TGT) to improve learning outcomes of students of class xi science 1 SMA Frater Makassar in the principal material of salt hydrolysis," *IOP Conf. Ser. Earth Environ. Sci.*, vol. 343, no. 1, 2019, doi: 10.1088/1755-1315/343/1/012228.

[4] S. Sutarno, A. Setiawan, A. Suhandi, I. Kaniawati, and D. H. Putri, "Keterampilan pemecahan masalah mahasiswa dalam pembelajaran bandul fisis menggunakan model problem solving virtual laboratory [Students' problem solving skills in learning physical pendulums using the virtual laboratory problem solving model]," *J. Pendidik. Fis. dan Teknol.*, vol. 3, no. 2, pp. 164–172, 2017, doi: 10.29303/jpft.v3i2.396.

[5] F. Fajriah, R. Salasi, S. Suryawati, and S. Fatimah, "Analysis of problem solving ability in social arithmetics," *J. Phys. Conf. Ser.*, vol. 1157, no. 4, 2019, doi: 10.1088/1742-6596/1157/4/042102.

[6] P. J. Frederick, "Student involvement: Active learning in large classes," *New Dir. Teach. Learn.*, vol. 1987, no. 32, pp. 45–56, 1987.

[7] S. Mahanal, S. Zubaidah, D. Setiawan, H. Maghfiroh, and F. G. Muhaimin, "Empowering college students' problem-solving skills through RICOSRE," *Educ. Sci.*, vol. 12, no. 3, 2022, doi: 10.3390/educsci12030196.

[8] D. A. K. Sari and E. P. Setiawan, "Literasi baca siswa indonesia menurut jenis kelamin, growth mindset, dan jenjang pendidikan: Survei PISA [Indonesian students' reading literacy by gender, growth mindset, and education level: PISA Survey]," *J. Pendidik. dan Kebud.*, vol. 8, no. 1, pp. 1–16, 2023, doi: 10.24832/jpnk.v8i1.3873.

[9] S. H. Hasasiyah, B. A. Hutomo, B. Subali, and P. Marwoto, "Analisis kemampuan literasi sains siswa SMP pada materi sirkulasi darah [Analysis of junior high school students' scientific literacy skills on blood circulation material]," *J. Penelit. Pendidik. IPA*, vol. 6, no. 1, pp. 5–9, 2020, doi: 10.29303/jppipa.v6i1.193.

[10] F. Huryah, R. Sumarmin, and J. Effendi, "Analisis capaian literasi sains biologi siswa sma kelas X Sekota Padang [Analysis of the achievement of biological science literacy of class X high school students in Padang City]," *J. Eksakta Pendidik.*, vol. 1, no. 2, p. 72, 2017, doi: 10.24036/jep.v1i2.70.

[11] N. F. Tillah and H. Subekti, "Analisis kemampuan literasi sains siswa SMP berdasarkan indikator dan level literasi sains [Analysis of junior high school students' scientific literacy skills based on scientific literacy indicators and levels]," *Edusaintek J. Pendidikan, Sains dan Teknol.*, vol. 12, no. 1, pp. 137–154, 2025.

[12] M. Taofiq, D. Setiadi, and G. Hadiprayitno, "Implementasi model pembelajaran inkuiri dan problem based learning (PBL) terhadap keterampilan generik sains biologi ditinjau dari kemampuan akademik siswa [Implementation of inquiry learning models and problem based learning (PBL) on generic biological science skills in terms of students' academic abilities]," *J. Penelit. Pendidik. IPA*, vol. 4, no. 2, pp. 29–33, 2018, doi: 10.29303/jppipa.v4i2.114.

[13] D. Ambarwati, U. B. Wibowo, H. Arsyiadanti, and S. Susanti, "Studi literatur: Peran inovasi pendidikan pada

pembelajaran berbasis teknologi digital [Literature study: The role of educational innovation in digital technology-based learning],” *J. Inov. Teknol. Pendidik.*, vol. 8, no. 2, pp. 173–184, 2022, doi: 10.21831/jitp.v8i2.43560

[14] S. Criollo-C, A. Guerrero-Arias, Á. Jaramillo-Alcázar, and S. Luján-Mora, “Mobile learning technologies for education: Benefits and pending issues,” *Appl. Sci.*, vol. 11, no. 9, 2021, doi: 10.3390/app11094111.

[15] Y. Ockta, U. Umar, A. Komaini, K. Firdaus, P. Padli, and M. Masrun, “Walk, run, jump and learn: Interactive multimedia for teaching locomotor skills in primary schools,” *Res. Dev. Educ.*, vol. 4, no. 1, pp. 1–11, 2024, doi: 10.22219/raden.v4i1.31831.

[16] M. Ramadayanty, S. Sutarno, and E. Risdianto, “Pengembangan E-Modul fisika berbasis multiple reprsentation untuk melatihkan keterampilan pemecahan masalah siswa [Development of multiple representation-based physics E-Modules to train students' problem-solving skills],” *J. Kumparan Fis.*, vol. 4, no. 1, pp. 17–24, 2021, doi: 10.33369/jkf.4.1.17-24.

[17] Y. A. Kurniawan, M. Rozaq, and A. Diana, “Penggunaan teknologi digital dalam pembelajaran sains dan olahraga untuk meningkatkan literasi dan pemahaman siswa [The use of digital technology in science and sports learning to improve student literacy and understanding],” *J. Sport. Sci. Heal. Tour. Mandalika*, vol. 5, no. 2, pp. 33–42, 2024.

[18] A. Febliza, Z. Afdal, and J. Copriady, “Improving Students’ Critical Thinking Skills: Is Interactive Video and Interactive Web Module Beneficial?,” *Int. J. Interact. Mob. Technol.*, vol. 17, no. 3, 2023.

[19] N. P. Pertiwi, S. Saputro, S. Yamtinah, and A. Kamari, “Enhancing critical thinking skills through STEM Problem-Based contextual learning: An integrated E-Module education website with virtual experiments.,” *J. Balt. Sci. Educ.*, vol. 23, no. 4, pp. 739–766, 2024.

[20] C. Huang, “Designing high-quality interactive multimedia learning modules,” *Comput. Med. Imaging Graph.*, vol. 29, no. 2–3, pp. 223–233, 2005.

[21] L. Tomas, M. Lasen, E. Field, and K. Skamp, “Promoting online students’ engagement and learning in science and sustainability preservice teacher education,” *Aust. J. Teach. Educ.*, vol. 40, no. 11, pp. 79–107, 2015.

[22] M. Linn, “Technology and science education: starting points, research programs, and trends,” *Int. J. Sci. Educ.*, vol. 25, no. 6, pp. 727–758, 2003.

[23] R. P. Aini, Y. Yuliati, B. Febriyanto, K. Majalengka, and J. Barat, “Eksplorasi media pembelajaran interaktif dalam pembelajaran IPA : Tinjauan sistematis terhadap literatur yang ada dan arah riset masa depan [Exploration of interactive learning media in science learning: A systematic review of existing literature and future research directions],” in *Seminar Nasional PPG FKIP UPR*, 2024, pp. 183–196.

[24] L. S. Vygotsky, *Mind in Society: The Development of Higher Psychological Processes*. Harvard University Press, 1978.

[25] K. Khairunnisak and K. Khairuni, “Pengembangan modul digital IPA berbasis kearifan lokal aceh untuk melatih kemampuan critical thinking siswa di era society 5.0 [Development of digital science modules based on Aceh local wisdom to train students' critical thinking skills in the era of society 5.0],” *J. Educ.*, vol. 07, no. 01, pp. 7041–7048, 2024.

[26] A. Meirbekov, I. Maslova, and Z. Gallyamova, “Digital education tools for critical thinking development,” *Think. Ski. Creat.*, vol. 44, p. 101023, 2022, doi: https://doi.org/10.1016/j.tsc.2022.101023.

[27] G. M. Morel and J. M. Spector, *Foundations of educational technology: Integrative approaches and interdisciplinary perspectives*. Routledge, 2022.

[28] M. N. Islam Sarker, M. Wu, Q. Cao, G. M. M. Alam, and D. Li, “Leveraging digital technology for better learning and education: A systematic literature review,” *Int. J. Inf. Educ. Technol.*, vol. 9, no. 7, pp. 453–461, 2019, doi: 10.18178/ijiet.2019.9.7.1246.

[29] J. Mezirow, *Learning as transformation: Critical perspectives on a theory in progress*. San Fransisco: CA: Jossey-Bass.

[30] Y. Falaq, N. A. Putri, M. Sholeh, and C. B. Utomo, “Teori pembelajaran transformatif pada pendidikan IPS [Transformative learning theory in social studies education],” *Harmon. J. Pembelajaran IPS dan PKN*, vol. 7, no. 2, pp. 90–97, 2022, doi: 10.15294/harmony.v7i2.61711.

[31] A. E. Jean Mary, “a Critical Review of Transformative Learning Theory,” *Int. J. Res. Anal. Rev.*, vol. 6, no. 2, pp. 812–820, 2019.

[32] R. Riduan, *Belajar mudah penelitian untuk guru, karyawan dan peneliti pemula [Easy research learning for teachers, employees and novice researchers]*. Bandung: Alfabeta, 2009.

[33] T. Solihati, “Penggunaan media pembelajaran kearifan lokal dan motivasi belajar untuk meningkatkan hasil belajar [Use of local wisdom learning media and learning motivation to improve learning outcomes],” *J. Educ.*, vol. 1, no. 2, 2022.

[34] R. A. Indah and M. Fadilah, “Literature review: Pengaruh media pembelajaran literasi visual terhadap hasil belajar biologi siswa SMA [Literature review: The influence of visual literacy learning media on high school students' biology learning outcomes],” *Biodik*, vol. 10, no. 2, pp. 188–198, 2024, doi: 10.22437/biodik.v10i2.33803.

[35] A. Kholidah and E. N. Savitri, “Pengaruh interactive E-Module berbasis masalah terhadap minat belajar dan

kemampuan pemecahan peserta didik [The influence of interactive problem-based E-Module on students' learning interest and problem-solving abilities]," *Proceeding Semin. Nas. IPA XII*, pp. 222–233, 2022.
[36] M. Munawir, A. Rofiqoh, and I. Khairani, "Peran media interaktif dalam meningkatkan motivasi belajar siswa pada mata pelajaran SKI di madrasah ibtidaiyah [The role of interactive media in increasing student learning motivation in SKI subjects in elementary madrasas]," *J. AL-AZHAR Indones. SERI Hum.*, vol. 9, no. 1, pp. 63–71, 2024, doi: 10.36722/sh.v9i1.2828
[37] S. Hartati and S. A. Siregar, "Pemanfaatan video pembelajaran dalam pembelajaran kimia untuk meningkatkan pemahaman konsep kimia [Utilization of learning videos in chemistry learning to improve understanding of chemical concepts]," *J. Chem. Educ. Integr.*, vol. 3, no. 2, pp. 111–119, 2024.
[38] A. Putri, U. Azzahra, and Z. S. Siregar, "Implementasi pembelajaran sains berbasis kearifan lokal dalam pembelajaran biologi: Sistematika literatur review [Implementation of local wisdom-based science learning in biology learning: Systematic literature review]," *Pros. Semnas BIO 2023*, pp. 1070–1078, 2023.
[39] N. G. A. P. WIDIASTARI and R. D. PUSPITA, "Penggunaan media pembelajaran digital dalam mengembangkan motivasi belajar siswa kelas iv SD inpres 2 Mambaru [The use of digital learning media in developing learning motivation of grade IV students of SD Inpres 2 Mambaru]," *Elementary*, vol. 4, no. 4, pp. 215–222, 2024.
[40] M. Tandikombong, T. Kabanga, P. Karuru, and R. Sampelolo, "Penggunaan aplikasi offline pada pembelajaran bahasa inggris di daerah pelosok di masa pandemi Covid-19 [The use of offline applications in English learning in remote areas during the Covid-19 pandemic]," *Abdimas Toddopuli*, vol. 4, no. 1, pp. 31–37, 2022.
[41] U. Usmeldi, R. Amini, and R. Darni, "Pelatihan pembuatan e-modul interaktif berbasis teknologi informasi untuk meningkatkan literasi digital guru sd dan smp di Kapau Kabupaten Agam [Training in creating interactive e-modules based on information technology to improve digital literacy of elementary and middle school teachers in Kapau, Agam Regency]," *J. Pengabdi. Pada Masy.*, vol. 8, no. 3, pp. 614–622, 2023, doi: 10.30653/jppm.v8i3.345.
[42] Irsan, "Implementasi literasi sains dalam pembelajaran ipa di sekolah dasar [Implementation of scientific literacy in science learning in elementary schools]," *J. Basicedu*, vol. 5, no. 6, pp. 5631–5639, 2021.