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DIGITALIZATION TRANSFORMATION OF ESD-ORIENTED E-CATALOGUE-BASED BIOLOGY LEARNING TO IMPROVE STUDENT LEARNING OUTCOMES

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ABSTRACT

Digitalization transformation in learning refers to using information and communication technology to improve the learning and teaching process. In the digital era, teaching materials can be accessed in electronic form. One of them is e-catalog. E-catalog is an innovative teaching material that is easy to learn anytime, anywhere, cheap, and easy to share. However, biology teaching materials in high school are still mainly textbooks that contain few aspects of Education for Sustainable Development (ESD). Various environmental problems currently arise, one of which is caused by the weak level of ecological literacy. This affects the value of learning outcomes of environmental change material. Environmental change materials contain ecological issues, including attitudes and behaviors towards the environment. Good environmental education can help increase public awareness of the importance of protecting the environment. ESD must be integrated into the curriculum content and implemented into learning. Therefore, it is necessary to digitally transform ESD-oriented e-catalog-based biology learning on environmental change to improve student learning outcomes. This study aimed to determine the validity, practicality, and effectiveness of ESD-oriented e-catalog-based learning on ecological change, which can enhance student learning outcomes. This research method uses the Research and Development (R&D) approach by adapting the ADDIE development model. This research uses a quasi-experimental design, with the research design used as a non-equivalent control group design, consisting of two class groups, namely the experimental and control classes. The data collection methods were observation, interviews, tests, and documentation. This research also uses validity, practicality, and effectiveness tests. The research instruments were observation sheets, interview sheets, validation instruments, practicality instruments, cognitive assessment instruments, and documentation. Furthermore, the data were analyzed descriptively and inferential statistics. ESD-oriented e-catalog on environmental change has a validity value of 96.40% with a very valid category.

The practicality value is 94.56%, with a convenient category. The t-test results for pre-test data obtained a t-count of -1.004 and from the t-table of 2.03224 with a significance of 0.319. As for the post-test data, the t-count value is 13.197, and the t-table is 2.03224, with a significance of 0.000. The value of t-count> t-table and significance less than 0.05 indicates an effect of using an ESD-oriented e-catalog on the concept of environmental change on students' cognitive learning outcomes. The effectiveness value of the N-Gain score for cognitive learning outcomes is 75.12%, which is a reasonably practical category. The digitalization transformation of ESD-oriented e-catalog-based learning is quite effective in student learning outcomes.

INTRODUCTION

Along with the times, learning technology continues to develop (Wahyudi, 2014; Rahadian, 2017; Jamun, 2018). This can be used to improve education quality (Zulfa, 2022; Sianturi & Simanjuntak, 2024). Technology will provide convenience in learning (Karuniawati, 2022; Manongga, 2022). According to Alimah (2022), learning technology is a series of theories and practices about designing, developing, utilizing, managing, and evaluating processes and resources for learning effectively and efficiently. Educators must constantly innovate to create exciting and effective learning for quality results (Wahyono, 2019; Nurillahwaty, 2022; Tareze & Astuti, 2022). One of them is through the development of learning media. Learning media is an intermediary or means of communication between teachers and students in learning to convey learning objectives (Yaumi, 2021). Using and selecting creative and innovative media can attract students' interest in learning and make it easier for students to remember what they have learned (Mardhiah & Akbar, 2018; Winatha, 2018; Nurfadhillah et al., 2021).

Utami et al. (2023) explained that most teachers and students use teaching materials that have yet to be digitized, such as textbooks, in learning biology in Brebes Regency high schools. Textbooks are media-printed materials that contain certain information or material arranged to facilitate teachers and students in achieving learning objectives (Riyana, 2012). Textbooks also have several areas for improvement, including being text-oriented, being too thick and heavy, needing more exercises to measure understanding of the material, and being easily damaged/torn (Asrowi et al., 2019). Therefore, alternative

solutions are needed to overcome the limitations of textbooks. One of them is the digitalization transformation of teaching materials.

Digital transformation in learning refers to using information and communication technology to improve learning and teaching (Andriani, 2016; Hidayat & Khotimah, 2019; Sawitri et al., 2019). In the digital era, teaching materials can be accessed electronically or digitally. Electronic teaching materials can support online and offline learning processes and face-to-face learning in the classroom (Delita & Berutu, 2022). Electronic learning media can improve student learning outcomes (Asrowi et al., 2019), self-efficacy, and student learning motivation (Delita & Berutu, 2022). According to Ramadhan et al. (2021), one electronic learning media that can be used is e-catalog.

E-catalog, an electronic-based catalog innovation, holds significant promise for education. As Daryanto (2010) notes, e-catalog is a visual media that overcomes space and time limitations, requiring minimal additional information. The use of e-catalogs has been shown to enhance student learning interest (Syahadat et al., 2023) and improve student learning outcomes (Aprilia, 2022). E-catalogs, designed to meet learning needs and rich in visual components, can incorporate various media, such as text, images, videos, and interactive multimedia, to present information in an engaging manner, leveraging current technological advancements (Delita & Berutu, 2022). The potential of e-catalogs to revolutionize learning is indeed exciting.

With various environmental problems on the rise, the weak level of environmental literacy is a significant contributing factor (Angreani et al., 2022; Santoso, 2023). This has a direct impact on the learning outcomes of environmental change material, which encompasses environmental issues, attitudes, and behaviors. Effective environmental education is crucial in raising public awareness about the importance of environmental protection (Masruroh, 2018; Therik & Lino, 2021). To this end, education for sustainable development (ESD) needs to be integrated into curriculum content and implemented into learning (Yuan et al., 2021). Given the current landscape, there is an urgent need to digitally transform ESD-oriented e-catalog-based biology learning on environmental change. This transformation can significantly enhance students' cognitive understanding of the environment and contribute to the creation of a balanced and sustainable environment.

This research represents a unique and innovative approach to e-catalog development. Unlike previous studies, this e-catalog is ESD-oriented, focusing on the concept of environmental change. The ESD-oriented e-catalog developed in this research is expected to meet valid and practical criteria, significantly improving the learning outcomes of SMA Negeri 1 Brebes students.

MATERIALS AND METHODS

This research, designed as a development research or Research and Development (R & D) project, was adapted from the ADDIE model developed by Anglada (2007). The model, consisting of five stages: Analysis, Design, Development, Implementation, and Evaluation, was chosen for its systematic approach. The primary objective was to produce an ESD-oriented e-catalog and test its validity, practicality, and effectiveness in learning. Data was collected using test instruments, observation, interviews, and documentation, all overseen by a team of experienced and knowledgeable researchers in the field of education and environmental studies.

At the analysis stage, preliminary research was conducted. This preliminary research was conducted to find problems and solutions in the learning process at school. Then, proceed with the design stage. The ESD-oriented e-catalog-based biology learning design and supporting instruments were prepared at this stage. Next is the development stage. ESD-oriented e-catalog on the concept of environmental change was developed through the Adobe Illustrator 2023 application on the desktop. After that, a validity test and practicality test were conducted. The validation test was conducted by two experts, namely lecturers who are experts in the field of learning media and experts in the field of ESD. Meanwhile, five practitioners have had at least 2 years of teaching experience or taken an S-2 education. The results of expert and practitioner validation were analyzed with a percentage formulated according to (Sugiyono, 2019) as follows :

$$P = \frac{F}{N} X100\%$$

Description:
P : Percentage Score
F : Number of scores obtained
N : The maximum number of scores

The data from the validity and practicality tests are then processed in qualitative sentences. The following are the validity criteria according to (Sugiyono, 2019).

Table 1. Criteria for validity

Interval	Validity level
90-100%	Very Valid
70-89%	Valid
50-69%	Moderately Valid
30-49%	Less Valid
20-29%	Not Valid

The following are the criteria for practicality according to (Sugiyono, 2019).

Table 2. Practicality criteria

Interval	Practicality level
90-100%	Very Practical
70-89%	Practical
50-69%	Moderately Practical
30-49%	Less Practical
20-29%	Not Practical

After the e-catalog met the valid and practical criteria, it moved into the implementation stage. Here, the ESD-oriented e-catalog was trialed in the classroom, with the students playing a crucial role as the primary data source for analysis. The trial at the school was conducted using the Quasi-Experimental Design method of the Non-Equivalent Control Group Design type. This method was applied to the class X students of SMA Negeri 1 Brebes, with samples taken from 2 classes, one serving as a control class and the other as an experimental class. Each class comprised 36 students.

Table 3. Non Equivalent Control Group Design

Group	Pretest	Treatment	Posttest
Experiment	T1	X	T2
Control	T1	-	T2

The pretest and posttest results in the control and experimental groups were compared to determine the average difference using the Independent Sample t-test statistics with SPSS. Furthermore, the N-Gain test was conducted with SPSS by comparing the posttest values in the experimental control class to measure the effectiveness of ESD-oriented e-catalog-based biology learning on the concept of environmental change. The following N-Gain effectiveness criteria, a robust evaluation tool, are presented in Table 4.

Table 4. N-Gain Effectiveness Criteria

Interval (%)	Category
< 40	Not Effective
40 – 55	Less Effective
56 – 75	Moderately Effective
> 76	Effective

Next is the evaluation stage. Evaluation is carried out at the final stage and at each stage in this study. The aim is to determine the success achieved at each stage and correct any deficiencies that exist at each stage.

RESULTS AND DISCUSSION

Preliminary research was conducted in the early stages of the study. The teaching materials used in biology learning in Brebes Regency high schools were analyzed at this stage. Interviews were conducted with teachers. Information about biology teaching materials used in public schools in Brebes Regency, including obtained from SMA Negeri 1 Brebes, SMA Negeri 2 Brebes, SMA Negeri 3 Brebes, SMA Negeri 1 Wanasari, SMA Negeri 1 Bulakamba, SMA Negeri 1 Tanjung, SMA Negeri 1 Ketanggungan, SMA Negeri 1 Larangan, SMA Negeri 1 Losari, SMA Negeri 1 Bumiayu, SMA Negeri 1 Salem and SMA Negeri 1 Paguyangan. Furthermore, one biology teaching material most widely used by students and teachers in these schools was selected, namely the biology book published by Erlangga, based on its widespread use and influence in the region. Some analyzed aspects included chapters, subchapters, paragraphs, and ESD sentences. The analysis of biology teaching materials results is based on the number of occurrences of the three pillars in the ESD perspective; namely, the economic pillar is only 43 sentences, the sociocultural pillar is 12 sentences, and the environmental pillar is 60 sentences. The appearance of the EDS pillars in class X biology teaching materials still needs to be improved. The appearance of each pillar shows different numbers in each chapter. This low number is due to the need to link sustainable social values to the existing material.

After obtaining preliminary research results, namely the low occurrence of ESD pillars in textbooks, a biology learning design or design was prepared as a solution to the existing problems. The learning design is based on an ESD-oriented e-catalog on environmental change. The e-catalog was developed using Adobe Illustrator application

with ESD-oriented specifications and has an attractive appearance, featuring engaging visuals, interactive elements, and a user-friendly interface.

Figure 1. ESD-oriented e-catalog cover

The e-catalog is a comprehensive resource, containing environmental change material in three sections: the first section is about environmental pollution, the second section contains facts about environmental change, and the third section is about global warming. As described on the initial page, each part of the material has markers. The following picture shows an example of ESD characteristics in the e-catalog.

Figure 2. ESD Markers in the E-catalog

Furthermore, as presented in the following figure, at the end of each material section in the e-catalog, there is a link to access the Learner Worksheet (LKPD).

Figure 3. Link to Access LKPD in the E-catalog

The LKPD is designed to be practical and user-friendly, aligning with learning activities. It contains a variety of student activities that empower learners to determine the impact and solve environmental problems in accordance with ESD aspects, namely environmental, socio-cultural, and economic. The complete e-catalog can be accessed at https://shorturl.at/064ud.

Following the development of the e-catalog, a rigorous validation process was undertaken. This involved in-depth discussions about the ESD-oriented environmental change e-catalog, compiled by researchers, with a panel of esteemed experts. The comprehensive e-catalog validation results are detailed in **Table 5**.

Table 5. E-catalog Expert Validity Test Results

No	Aspect	Score Validator		Maximum Score	Description
		Validator 1	Validator 2		
1.	Introduction	30	27	30	Can be used with revision, Average percentage 96.40% very valid category
2.	Content Feasibility	29	29	30	
3.	Learning	34	35	35	
4.	Supporting Material Presentation	14	13	15	
5.	Completeness of Presentation	15	15	15	
	Total Score	122	119	125	
	Validity Level	97,60%	95,20%	100,00%	
	Category	Very Valid	Very Valid		

Based on the validation results, the average percentage of expert validators is 96.40% with a very valid category. The e-catalog, while promising, requires our collective attention. On the initial page, it is necessary to explain the letters of the ESD reorientation symbol, and on the pictures in the e-catalog, it is necessary to add a

description or identity of the image. Your input in these revisions is crucial for the success of our project.

At this stage, the cognitive assessment instrument, a key tool for evaluating the user's understanding and interaction with the e-catalog, was also validated. The results of the cognitive question instrument validation are presented in **Table 6**.

Table 6. Cognitive Assessment Instrument Validity Test Results

No	Aspect	Score Validator		Maximum Score	Description
		P1	P2		
1.	Content	19	19	20	Can be used with revision, Average percentage 94.29% very valid category
2.	Language	15	13	15	
	Total Score	34	32	35	
	Validity Level	97,14%	91,43%	100,00%	
	Category	Very Valid	Very Valid		

Based on the validation results, the average percentage of expert validators is 94.29%, with a very valid category. This thorough validation process ensures the reliability of the cognitive question instruments, which can be used with revisions by adjusting the question context to the mental level.

In addition to the validity test, the ESD-oriented e-catalog was also tested for practicality by five practitioners. The results of the ESD-oriented environmental change e-catalog practicality test, which demonstrate its practical applicability in real-world settings, are presented in **Table 7**.

Table 7. Practicality Test Results of the ESD-oriented Environmental Change E-catalog

Practitioners	Total Score obtained	Percentage (%)	Practicality Level
P1	125	100,00%	Very Practical
P2	122	97,60%	Very Practical
P3	117	93,60%	Very Practical
P4	112	89,60%	Practical
P5	115	92,00%	Very Practical
Percentage (%) Average	118,2	94,56%	Very Practical

Data in **Table 7** shows that the level of practicality of the ESD-oriented environmental change e-catalog with a total of five practitioners obtained efficient results by four practitioners and practical by one practitioner. The average percentage is 94.56% at the efficient level. This is in line with the opinion of Irawan et al. (2021), which states that using practical learning media will benefit the learning process, which can clarify information related to learning materials to get quality learning and improve learning processes and outcomes. In addition to data in the form of ESD-oriented environmental

change e-catalog practicality assessment scores, there are several inputs from practitioners, namely the need to enlarge the symbol letters so that they are more clearly visible and ensure the ability of the devices owned by students to support access to the use of e-catalogs. This feedback was followed up according to the practitioners' feedback. Based on the data and practitioners' information, the ESD-oriented environmental change e-catalog can be used without revision.

At this stage, the cognitive assessment instrument's practicality test was also conducted. The results of the practicality test of the cognitive learning outcomes instrument are presented in **Table 8**.

Table 8. Results of Practicality Test of Cognitive Learning Outcomes Instrument

Practitioner	Number of Scores obtained	Percentage (%)	Practicality Level
P1	100	100,00%	Very Practical
P2	34	97,14%	Very Practical
P3	33	94,29%	Very Practical
P4	32	91,43%	Very Practical
P5	33	94,29%	Very Practical
Percentage (%) Average	46,40	95,43%	Very Practical

Data in Table 8 shows that the instrument of cognitive learning outcomes has achieved efficient results, with an average percentage of 95.43%. This success is further validated by practitioner feedback, which suggests that the introduction of a wider variety of questions could potentially enhance these outcomes even further.

Following the meticulous selection of e-catalogs based on valid and practical criteria, the research progressed to the implementation stage. Here, the ESD-oriented e-catalog trial was conducted in the classroom to assess its effectiveness. The thoroughness of the process is evident in the use of cognitive assessment instruments with 20 items, previously tested for both validity and practicality. The average score of students' cognitive learning outcomes is presented in **Table 9** below, providing a comprehensive view of the research findings.

Table 9. Average Score of Cognitive Learning Outcomes

Activity	Group	N	Mean
Pre-test	Experiment	36	52,22
	Control	36	54,72
Post-test	Experiment	36	88,47
	Control	36	67,08

Before delving into the impact of the ESD-oriented e-catalog on the understanding of environmental change and its influence on cognitive scores, it was crucial to ensure the robustness of our data. To this end, we conducted a normality test and homogeneity test on the data from both the experimental and control groups. The results of these tests, along with the t-test, are presented in **Table 10** below. These findings are of significant importance and will be further discussed in our subsequent analysis.

Table 10. Results of Normality Test, Homogeneity Test and T-test on Cognitive Value Score

Activity	Group	Norm	Hom	t- count	t- table	Sig. t Test
Pre-test	Experiment	0,146	0,849	-1,004	2,03224	0,319
	Control	0,196				
Post-test	Experiment	0,054	0,784	13,197	2,03224	0,000
	Control	0,081				

The data presented in **Table 9** underscores the significant improvement in the experimental group. The average score of the pre-test cognitive value of the experimental group was 52.22, slightly lower than the control group's 54.72. However, the average post-test cognitive score of the experimental group soared to 88.47, surpassing the control group's 67.08. This substantial increase in post-test scores in the experimental class validates the research by Aprilia (2022) that the use of e-catalogs as a learning medium can significantly enhance student interest in education, thereby improving student learning outcomes (Listiyani et al., 2022.; Syahadat et al., 2023). The ESD-oriented e-catalog, in particular, allows students to delve into the concept of environmental change from socio-cultural, economic, and ecological perspectives.

The data presented in Table 10 is a testament to the thoroughness of the statistical tests conducted. The Normality Test, using Shapiro-Wilk, revealed the significance of each experimental class pre-test data (0.146) and control class (0.196), as well as the post-test data for each experimental class (0.054) and control class (0.081). The homogeneity test, employing the Levene test, further confirmed the robustness of the study, with the results of each pre-test significance (0.849) and post-test significance (0.784) demonstrating the consistency of the data.

The t-test results for the pre-test data obtained a 't-count' of -1.004. The 't-count' is a measure of the difference between the means of the two groups, in this case, the control and experimental classes. From the 't-table' of 2.03224 with a significance of 0.319, we can determine the critical value of the t-distribution for a given significance level.

Because the t-count, t-table, and importance are more significant than 0.05, there is no difference in the average value of the control and experimental classes. This is because neither class received treatment, so there was no difference between the control class and the experimental class before treatment, namely, the application of ESD-oriented e-catalog on the concept of environmental change in the experimental class.

The t-test results for post-test data further underscore the impact of the ESD-oriented e-catalogs on students' cognitive learning outcomes. With a t-count value of 13.197 and a t-table of 2.03224 with a significance of 0.000, the results are clear-the t-count value> t-table and significance less than 0.05. This unequivocally indicates the positive effect of the application of ESD-oriented e-catalogs on the concept of environmental change on students' cognitive learning outcomes. These findings are in line with the research by Rahmawati (2022) and Santoso (2023), which also found that ESD in teaching can significantly impact students' cognitive learning outcomes.

Furthermore, the post-test scores of cognitive learning outcomes in the experimental and control classes were tested for N-Gain. The N-Gain Test is a measure of the effectiveness of a learning intervention. It compares the post-test scores to the pre-test scores to determine the amount of learning that has occurred. The results of the N-Gain Test of Post-test Cognitive Learning Outcomes of Experimental and Control Classes are presented in **Table 11.**

Table 11. N-gain Test Results

Descriptives

	Kelompok			Statistic	Std. Error
NGain_persen	1	Mean		75.1170	2.53843
		95% Confidence Interval for Mean	Lower Bound	69.9637	
			Upper Bound	80.2703	
		5% Trimmed Mean		75.4036	
		Median		80.0000	
		Variance		231.971	
		Std. Deviation		15.23059	
		Minimum		37.50	
		Maximum		100.00	
		Range		62.50	
		Interquartile Range		23.21	
		Skewness		-.351	.393
		Kurtosis		-.524	.768
	2	Mean		26.0002	1.80827
		95% Confidence Interval for Mean	Lower Bound	22.3292	
			Upper Bound	29.6711	
		5% Trimmed Mean		25.6661	
		Median		27.2727	
		Variance		117.714	
		Std. Deviation		10.84962	
		Minimum		9.09	
		Maximum		50.00	
		Range		40.91	
		Interquartile Range		18.45	
		Skewness		.301	.393
		Kurtosis		-.527	.768

The N-Gain Test Post-test of Cognitive Learning Outcomes of the Experimental Class resulted in a significant 75.12%. This indicates that the ESD-oriented e-catalog on the concept of environmental change, which was developed, is indeed compelling enough to enhance students' cognitive learning outcomes. The high N-gain value in the experimental group is consistent with Aprilia's perspective (2022) and other research, which suggests that e-catalogs are an effective learning tool, boosting student motivation and learning outcomes. E-catalogs, as demonstrated by Listiyani et al. (2022), can serve as versatile and effective biology learning media, stimulating student interest in learning (Syahadat et al., 2023). The integration of ESD perspective values (socio-cultural, economic, and environmental) into e-catalog teaching materials can significantly enrich learning resources for teachers and students, thereby enhancing student learning outcomes.

CONCLUSION

The ESD-oriented e-catalog, focusing on the concept of environmental change, has a validity value of 96.40%, with a very valid category. The practicality value, emphasizing its user-friendliness and ease of use, is 94.56%, with a convenient category. The effectiveness value gets an N-Gain score for cognitive learning outcomes of 75.12%, with a reasonably effective category.

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REFERENCES

Alimah, S. (2022). *Teknologi Pembelajaran Biologi Di Era Post Pandemi Covid 19 S Alimah*.

Andriani, T. (2016). Sistem pembelajaran berbasis teknologi informasi dan komunikasi. *Sosial Budaya*, *12*(1), 117–126.

Anglada, D. (2007). *An Introduction to Instructional Design: Utilizing a Basic Design Model*.

Angreani, A., Saefudin, S., & Solihat, R. (2022). Virtual laboratory based online learning: Improving environmental literacy in high school students. *JPBI (Jurnal Pendidikan Biologi Indonesia)*, *8*(1), 10–21. https://doi.org/10.22219/jpbi.v8i1.18120

Aprilia, R. (2022). *Efektivitas model PBL berbantuan E-katalog materi sistem gerak manusia pada motivasi belajar dan hasil belajar siswa SMA*. UNNES.

Asrowi, Hadaya, A., & Hanif, M. (2019). The impact of using the interactive e-book on students' learning outcomes. *International Journal of Instruction*, *12*(2), 709–722. https://doi.org/10.29333/iji.2019.12245a

Daryanto. (2010). *Media Pembelajaran*. Gava Media.

Delita, F., & Berutu, N. (2022). *Online Learning: The Effects Of Using E-Modules On Self-Efficacy, Motivation And Learning Outcomes*.

Hidayat, N., & Khotimah, H. (2019). Pemanfaatan teknologi digital dalam kegiatan pembelajaran. *Jurnal Pendidikan Dan Pengajaran Guru Sekolah Dasar (JPPGuseda)*, *2*(1), 10–15.

Irawan, A., Arif, M., & Hakim, R. (2021). *PYTHAGORAS: Jurnal Program Studi Pendidikan Matematika, 10(1): 91-100 Kepraktisan Media Pembelajaran Komik Matematika Pada Materi Himpunan Kelas VII SMP/MTs*.

Jamun, Y. M. (2018). Dampak teknologi terhadap pendidikan. *Jurnal Pendidikan Dan Kebudayaan Missio*, *10*(1), 48–52.

Karuniawati, A. (2022). Peran teknologi dalam pembelajaran merdeka belajar di Era 4.0. *Prosiding Seminar Nasional PGSD UST*, *1*(1), 34–42.

Listiyani, D., Biologi, J. P., Matematika, F., Ilmu, D., Alam, P., Negeri, U., & Budiwati, Y. (2022). Penyusunan E-Katalog Keanekaragaman Pteridophyta Di Lingkungan Sma Negeri 2 Temanggung Sebagai Media Pembelajaran Biologi. In *Maret* (Vol. 8, Issue 1). https://journal.student.uny.ac.id/

Manongga, A. (2022). Pentingnya teknologi informasi dalam mendukung proses belajar mengajar di sekolah dasar. *Prosiding Seminar Nasional Pendidikan Dasar*.

Mardhiah, A., & Akbar, S. A. (2018). Efektivitas media pembelajaran terhadap hasil belajar kimia siswa SMA Negeri 16 Banda Aceh. *Lantanida Journal*, *6*(1), 49–58.

Masruroh, M. (2018). Membentuk Karakter Peduli Lingkungan Dengan Pendidikan. *Jurnal Geografi Gea*, *18*(2), 130–134.

Nurfadhillah, S., Pertiwi, D., Pratiwi, D. I., Dewi, E. P., Saidah, M., & Nurhaliza, S. (2021). *Pengembangan media poster dalam pembelajaran IPA kelas IVB SD Negeri Cikokol 3*.

Nurillahwaty, E. (2022). Peran Teknologi dalam Dunia Pendidikan. *Seminar Nasional Program Pascasarjana Universitas Pgri Palembang*, *1*, 81–85.

Rahadian, D. (2017). Teknologi informasi dan komunikasi (tik) dan kompetensi teknologi pembelajaran untuk pengajaran yang berkualitas. *Teknologi Pembelajaran*, *2*(1).

Rahmawati, S. (2022). *Pengembangan Perangkat Pembelajaran Pencemaran Lingkungan Berorientasi Education for Sustainable Development (ESD) Untuk Meningkatkan Literasi Lingkungan Dan Hasil Belajar Siswa MTs*. UPGRIS.

Ramadhan, F. N., Sunardi, S., & Musadad, A. A. (2021). Media Katalog Digital Untuk Pembelajaran Sejarah Di Masa Pandemi Covid-19. *Diakronika*, *21*(2), 83–100. https://doi.org/10.24036/diakronika/vol21-iss2/220

Riyana, C. (2012). *Media pembelajaran*. KEMENAG RI.

Santoso, R. (2023). *Pengembangan Model Pembelajaran IPA Berbasis Sustainable Development pada Materi Pemcemaran Lingkungan untuk Meningkatkan Literasi Lingkungan dan HAsil Belajar Kognitif Siswa SMP*. UPGRIS.

Sawitri, E., Astiti, M. S., & Fitriani, Y. (2019). Hambatan dan tantangan pembelajaran berbasis teknologi informasi dan komunikasi. *Prosiding Seminar Nasional Program Pascasarjana Universitas Pgri Palembang*.

Sianturi, M. V., & Simanjuntak, M. P. U. (2024). Pengembangan Kompetensi Profesionalisme Guru di Era Digital. *Jurnal Pendidikan Agama Dan Teologi*, *2*(1), 180–190.

Sugiyono. (2019). *Metode Penelitian Kuantitatif, Kualitatif, dan R &D*. Alfabeta.

Syahadat, D. A., Lukman Nulhakim, & Dwi Indah Suryani. (2023). Pengembangan Media Pembelajaran Berbasis e-Katalog untuk Menumbuhkan Minat Belajar Siswa Kelas VIII SMP pada Tema Makanan Berbahaya. *Jurnal Pendidikan Mipa*, *13*(2), 423–429. https://doi.org/10.37630/jpm.v13i2.984

Tareze, M., & Astuti, I. (2022). Model Pembelajaran Kolaborasi Sdgs Dalam Pendidikan Formal Sebagai Pengenalan Isu Global Untuk Meningkatkan Kesadaran Sosial Peserta Didik. *Visipena*, *13*(1), 42–53.

Therik, J. J., & Lino, M. M. (2021). Membangun Kesadaran Masyarakat Sebagai Upaya Pelestarian Lingkungan. *Jurnal Administrasi Publik*, *17*(1), 89–95.

Utami, D. T., Roshayanti, F., Dewi, R. S., & Nugroho, A. S. (2023). *Analisis Bahan Ajar Biologi Sma Ditinjau Dari Muatan Sustainable Development Goals (SDGs)*. *09*(01), 8–17. https://doi.org/10.26877/jp3.v9i1.17029

Wahyono, H. (2019). Pemanfaatan teknologi informasi dalam penilaian hasil belajar pada generasi milenial di era revolusi industri 4.0. *Proceeding of Biology Education*, *3*(1), 192–201.

Wahyudi, N. (2014). Pemanfaatan blog sebagai media pembelajaran interaktif. *Jurnal Studi Islam Panca Wahana*, *12*(10), 84–94.

Winatha, K. R. (2018). Pengembangan e-modul interaktif berbasis proyek mata pelajaran simulasi digital. *Jurnal Pendidikan Teknologi Dan Kejuruan*, *15*(2).

Yaumi, M. (2021). *Media dan Teknologi Pembelajaran Edisi Kedua*. Prenada Media. https://books.google.co.id/books?id=g0VIEAAAQBAJ

Yuan, X., Yu, L., & Wu, H. (2021). Awareness of sustainable development goals among students from a chinese senior high school. *Education Sciences*, *11*(9). https://doi.org/10.3390/educsci11090458

Zulfa, N. I. L. (2022). *Pengembangan e-modul ipa terpadu tema pemanasan global berbasis problem based learning untuk meningkatkan pemahaman siswa kelas vii SMP*.