JPPIPA 11(2) (2025)

Jurnal Penelitian Pendidikan IPA

Journal of Research in Science Education

http://jppipa.unram.ac.id/index.php/jppipa/index

Development of PBL-Based Learning Media Using Smart Apps Creator to Improve Science Learning Outcomes for Grade IV Elementary School Students

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Received: November 05, 2024
Revised: January 06, 2025
Accepted: February 25, 2025
Published: February 28, 2025

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DOI: 10.29303/jppipa.v11i2.10288

Abstract: Low student learning outcomes are influenced by the use of new learning models and media that are still not ideal for science and the science learning process. Given that these challenges require the development and evaluation of learning media that aim to improve the educational achievements of children in grade four, this study aims to do so. The maker of smart applications based on PBL (Problem Based Learning) content about the Form of Matter and Its Changes is the learning media that is developed. Research and development, or RnD, is the process used, with the ADDIE model as the development framework. Participants in this study numbered 27 people from grade IV of SD Negeri 1 Brobot. Both pre- and post-test methods, as well as non-test methods such as observation, interviews, questionnaires, and documentation, were used in the data collection process. The media validator reached a very feasible level of 93.3% and the material validator 87%. A significant difference (Sig. 0.00 <0.05) was shown by the t-test between the pretest and posttest data. The N-gain test shows moderate requirements, with a small scales value of 0.61 and a large scales value of 0.64. Based on these findings, it is reasonable to conclude that the developer of PBL-based application learning media has created practical and effective substance-based content to be used in improving the educational outcomes of fourth grade students of SD Negeri 1 Brobot.

Keywords: Learning Media; Learning outcomes; PBL; Smart apps creator

Introduction

Improving the quality of education is an important responsibility of schools as formal educational institutions. According to Chavda & Nisarga (2023); Holmes & Tuomi (2022);, education consists of a system of rules that help children learn and grow into good, intelligent, disciplined, socially competent, and religious individuals. According to Cai et al. (2023); González Hernández (2022), education is a methodical process in which teachers guide students to develop character in all areas. The ultimate goal is for everyone to achieve physical and spiritual well-being and uphold noble values in life. According to Deng et al. (2024); Karatsiori (2023), good character, dedication, logic, and social competence are the ultimate goals of education. Because the advancement of science and technology is currently happening very quickly, "modern education" means emphasizing science and technology (Wang et al., 2010; Wang et al., 2024). This inspires teachers and students to think outside the box in order to keep up with the rapid pace of change. One way technological advances will change education is through the introduction of new subject matter (Ali et al., 2024; Mhlanga, 2024). The new policy of "Independent Learning" as a curriculum is a

How to Cite:
Wulandari, N. G., & Wulandari, D. (2025). Development of PBL-Based Learning Media Using Smart Apps Creator to Improve Science Learning Outcomes for Grade IV Elementary School Students. *Jurnal Penelitian Pendidikan IPA*, *11*(2), 1147–1156. https://doi.org/10.29303/jppipa.v11i2.10288

product of the 5.0 revolution currently underway in Indonesia.

The current Indonesian curriculum has been reformed into an autonomous curriculum (Afandi et al., 2022; Puad & Ashton, 2023). It is believed that an independent curriculum, if implemented, offers children the opportunity to learn and hone their innate abilities in an environment free from distraction, anxiety, and pressure. According to Lavonen (2020); Wahlström, (2023), when compared to the independent curriculum, this curriculum contains one difference between the two curricula, namely the 2013 curriculum uses subject-based learning, while the independent curriculum uses integrated thematic learning. If the autonomous curriculum combines science and social studies content in science, the 2013 curriculum maintains a different curriculum for each subject and creates its own set of teaching materials. Finally, the 2013 curriculum distinguishes between lower elementary school levels (grades I–III) and upper levels (grades IV–VI). The first level requires students to achieve learning objectives at a high level and the second level requires repeating classes if unsuccessful. Phase A covers grades I and II, phase B covers grades III and IV, and phase C covers grades V and VI in the Merdeka curriculum, but this is not the case.

Students can continue to the next level if they are unable to complete the learning outcomes in grade one (Kintu et al., 2017; Moses & Mohamad, 2019). Ability testing is an integral part of the Merdeka curriculum. Education and technological progress are highly dependent on science and natural science content. As previously stated Nur'ariyani et al. (2023); Zamiri & Esmaeili (2024);, the goals of science education in elementary schools are to foster interest and appreciation for scientific methods and constructive views on the role of technology in modern society. Gain an understanding of the methods used for problem solving, decision making, and environmental science. Learn scientific topics that you can use in your daily life and expand your knowledge of these topics. Participate in keeping the natural environment safe, clean, and undisturbed. As a result of God's work, respect the rules of nature and its contents. Researchers in Purbalingga Regency and SD Negeri 1 Brobot found that students' attention was still focused on the less interesting lecture method in teaching science.

As a result, students in this school feel bored with science lessons and lack innovation in lessons. Although the results are not optimal, this institution has begun to implement a student-centered Problem-Based learning approach. On the other hand, there are problems with learning resources that only rely on internet and YouTube videos and images. As a result, not all students respond appropriately, think critically, and demonstrate reasonable reasoning in class. The findings indicate the absence of creative pedagogical tools in science classes. As a result, teaching materials and strategies are needed that can improve the quality of student learning and the level of agency during the learning process. According to Abdulrahaman et al. (2020); Haleem et al. (2022), One of the tools that can be used to facilitate the learning process and achieve educational goals effectively and quickly is learning media.

Method

In a broad sense, this research is research that seeks to advance a medium. According to Falahat et al. (2024); Garrido-Moreno et al. (2024), development research is a method to make a system more useful by creating new products or improving existing products. Chukhray et al. (2022), states that R&D is a research method used for the production and evaluation of a particular item. The learning outcomes of fourth grade elementary school students about the properties and changes in the state of matter will be improved through the creation of smart applications based on PBL as a learning medium.

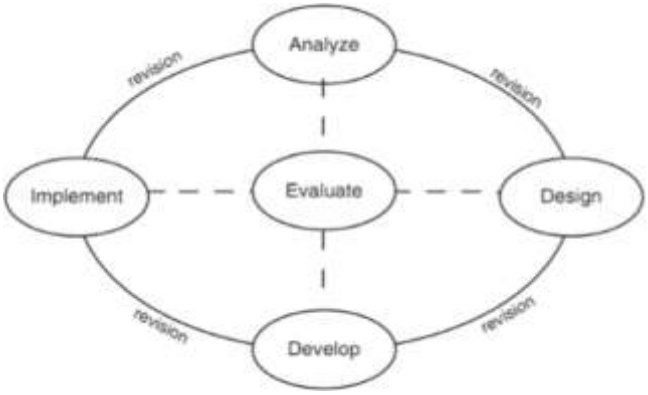

Figure 1. ADDIE Research Design

In the analysis step, researchers look for problems by analyzing needs, student characteristics, learning environments, and other factors. The research was conducted through interviews and observations to identify media and learning methods that students need, that interest them, and that can be applied according to their learning context. The formula used is as follows.

$$P = \frac{\Sigma x}{\Sigma xi} \times 100 \quad (1)$$

Information:
P = Score percentage
Σx = The sum of the respondent's answer values in one item
Σxi = The number of ideal scores in one item

Table 1. Criteria for Teacher and Student Needs Questionnaire

Percentage (%)	Criteria
81 – 100	Strongly agree
61 – 80	Agree
41 – 60	Disagree
21– 40	Disagree
0 – 20	Strongly disagree

Researchers create learning media products based on smart problem-based learning (PBL) applications throughout the design stage. The process begins with the synthesis of ideas, media, background information, and images related to the physical properties and transformations of substances taken from various sources, such as course materials, student publications, and online sources. When creating or developing new products, these design results are used as benchmarks. Researchers provide educational content for Android devices in the form of applications. All prepared application assets are developed during the development stage. Related material and media experts then conduct validation tests. To measure the validity of the product and collect feedback on how to make it better, validation tests are conducted. As for calculating the percentage of validation results based on the validation obtained from the validator using the following formula.

$$\text{V-ah} = \frac{TSe}{TSh} \times 100\% \quad (2)$$

Description:

V-ah: Expert Validation

TSe: Total empirical score achieved

TSh: Total maximum score

Table 2. Expert Validation Instrument Criteria

Score (%)	Validation Category
85 – 100	Very Valid
69 – 84	Valid
53 – 68	Quite Valid
37 -52	Less Valid
20 - 36	Not Valid

To find out whether the media can improve the learning outcomes of fourth grade students, researchers conducted a media trial using the materials and modifications that had been made. Analysis of teacher responses to the media, there are 5 categories used, namely, 1 (strongly disagree), 2 (disagree), 3 (quite agree), 4 (agree), 5 (strongly agree). The formula used is as follows.

$$\text{P} = \frac{F}{N} x100\% \quad (3)$$

Description:

P = percentage number = score obtained

AND = maximum score

Table 3. Teacher Response Questionnaire Criteria

Score (%)	Criteria
82 – 100	Very good
63 – 81	Good
44 – 62	Enough
25 - 43	Less

The student response questionnaire to the media uses 2 answer choices, namely a score of 1 (agree) and a score of 0 (disagree). The formula used is as follows.

$$\text{P} = \frac{F}{N} x100\% \quad (4)$$

Description:

P = percentage number = score obtained

AND = maximum score

Table 4. Student Response Questionnaire Criteria

Score (%)	Criteria
82 – 100	Very good
63 – 81	Good
44 – 62	Enough
25 - 43	Less

The effectiveness of student learning outcomes can be done by analyzing students' cognitive learning outcomes by calculating the scores that students have obtained and testing the results before treatment and the results after treatment. Initial data analysis consists of a normality test. The normality test is used in this study to determine whether the data is normally distributed or not.

Table 5. Testing Criteria for Normality Test

Results	Information
If the significance value ≤ 0.05	Ho rejected
If the significance value > 0.05	Ho accepted

The final data analysis consisted of paired samples T-Test and N-Gain Test. The Paired Samples T-Test or paired sample t-test was conducted to determine the average difference between two paired samples. (Stevens et al., 2018; Wang et al., 2022), stated that paired samples are used in sample groups that include the same subjects but experience two different treatments, such as before and after being treated. In this study, researchers used SPSS version 24 to test the results before treatment and the results after treatment with the paired samples t-test. This t-test can be used on data that is normally distributed parametrically.

Tabel 6. Test Testing Criteria Paired Samples T-Test

Results	Information
If -t count ≥ -t table or t count ≤ t table	Ho received
If -t count < -t table or t count > t table	Ho was rejected

Then the gain index analysis is used to calculate the assessment between the pretest and posttest scores. In this study, the gain in question is the normalized gain (N-gain). N-Gain is the normalization of the gain obtained from comparing the difference between the pretest and posttest scores with the difference in the Ideal Minimum Score (SMI) and pretest on the science subject matter after using the Smart Apps Creator learning media Form of Substance and Its Changes. The normalized gain Formula 5.

Table 7. Decision Making Based on the Significance of the Paired Samples T-Test

Results	Description
If the significance value ≤ 0.05	Ho accepted
If the significance value > 0.05	Ho rejected

$$\text{N} - \text{Gain} = \frac{\text{Posttest score} - \text{pretest score}}{\text{Maximum score} - \text{pretest score}} \quad (5)$$

Description:
N-gain = the magnitude of the gain factor
Posttest score = final test score after being given treatment
Pretest score = initial value before being given treatment
Maximum score = maximum value

Table 8. Average Increase Test (N-Gain)

Interval	Criteria
N-Gain ≥ 0.70	High
0.30 ≤ N-Gain ≤ 0.70	Medium
N-Gain < 0.30	Low

Result and Discussion

Analysis

The needs analysis phase, learner characteristics, and learning environment form this stage. Observations and interviews are conducted as part of the needs analysis to determine the types of media needed by students.

Teacher and Student Needs Questionnaire Analysis

Table 9. Teacher and Student Needs Questionnaire Results

Questionnaire Results	Percentage (%)
Teacher	84
Students	93
Average	88.50

Table 9 shows the results of the teacher and student needs questionnaire. The average results of the teacher and student needs questionnaire for the development of the Smart Apps Creator form Substance and Its Changes media were 88.5% and fell into the strongly agree criteria (Silaban et al., 2024). Students are highly engaged in learning according to interview and observation data, while teachers continue to rely on traditional learning tools such as textbooks and lectures (Attard & Holmes, 2022; Hollister et al., 2022; Tsehay et al., 2024)). As a result, students lose interest and fail to understand the points conveyed by the instructor. Therefore, interesting educational materials are needed to help students understand the material. Media that attract students as learners are identified through characteristic analysis.

Thanks to technological advances, many students can now use smartphones. Observations show that students enjoy watching movies, playing games, and other similar activities on smartphones. This is because of its user-friendly design, vibrant graphics, and animation features. Therefore, media that is visually appealing and easy to understand is needed, including color, typography, and images. Examining the classroom environment through the lens of student experience, circumstances, and financial capabilities. There needs to be a change in the current teaching style, which relies heavily on lectures and provides little room for student participation; therefore, a problem-based learning approach is essential. The school's internet connection is also known to be ideal for academic purposes. Therefore, educational institutions can utilize digital learning resources.

Design

As determined based on the examination of the results of interviews and observations conducted. For educational media, researchers draw storyboards. The initial stage in developing learning media about the state of matter and its changes is by creating a storyboard. Smart Apps Creator 3.0 is the program used. As an additional note, scientists have also begun to prepare visuals, audio, materials, and others for development. In addition, material and media experts can fill out a product validation form to help validate the evaluation tool. Then, to find out how well the learning materials created are able to improve students' high-level thinking skills in grade IV, there are 25 multiple-choice questions in the pretest and posttest.

Development

Development involves utilizing previously produced designs to develop learning media. Learning

objectives and achievements inform the development of media used to create PBL-based smart applications. Combining the idea of Problem-Based Learning (PBL) syntax, this smart application maker media includes videos that illustrate the state of matter and its changes, quizzes, and visuals that match the content to make it easier to understand. The smart application media maker was created in Canva with the help of a number of objects and images that represent the form and transformation of matter (Putri & Jumardi, 2023). This media was produced with a resolution of 1080 x 1920 mm so that it is compatible with the screens found on laptops and Android devices. The final result of this media is an Android application and an executable Windows file for laptops; Users can use it directly after installation via an internet connection, but it can also be used offline, except for doing quizzes. The author of the smart application media section created the substance, and included its modifications:

Figure 2. Front part

Figure 3. Menu section

Figure 4. CP and TP Learning 1

Figure 5. CP and TP Learning 2

Figure 6. PBL Syntax Learning 1

Figure 7. PBL Syntax Learning 2

Figure 8. Learning Quiz 1

Figure 9. Learning Quiz 2

Expert validation, the next step is to bring in material experts from the scientific material field and media experts from the multimedia field. This is what the expert validation evaluation looks like.

Table 10. Expert validation value

Aspect	Validation Index (%)	Description
Validation	87	Very worthy
Material expert	93.30	Very worthy

Based on Table 10, the assessment of the validation of the material expert validator gave a result of 87%, which means it can be implemented. Criticism and recommendations to include the LKPD barcode to make it easier to access came from the material expert validator. On the other hand, it was considered feasible based on the evaluation results obtained by the media expert validator of 93.3%. This finding shows that educational material on the form of matter and its changes is a good candidate for further evaluation.

Implementation

Students evaluate the latest learning material which is a product of the PBL smart application maker. The main purpose of this study was to determine whether the use of learning media by fourth grade students improves academic achievement or not. Students were evaluated by giving a pretest and posttest. Small-scale and large-scale trials have been conducted. The normality test was used to conduct the t-test and N-gain test, which were then used to conduct the effectiveness test. The researchers started with a pilot study with only nine students. These students were given pre- and post-tests, and the results were as follows:

Table 11. Small-scale normality test

Parameters	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Small Scale Pretest	0.215	9	0.200*	0.867	9	0.113
Small Scale Posttest	0.167	9	0.200*	0.957	9	0.771

*. This is a lower bound of the true significance.
a. Lilliefors Significance Correction

The initial finding of the normality test was 0.113, and the subsequent result was 0.771, as seen in the small-scale normality test table above. Small-scale data on student learning outcomes should follow a normal distribution.

Table 12. Small scale T-test

Pair 1	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference		t	df	Sig. (2-tailed)
				Lower	Upper			
Small Scale Pretest - Small Scale Posttest	-27.222	11.476	3.825	-36.043	-18.401	-7.116	8	0.000

Table 13. Small-scale N-gain test

	N	Min	Max	Mean	Std. Deviation
N_Gain	9	0.43	0.85	0.6171	0.14222
Valid N (listwise)	9				

The results show a difference of 0.000 between the average scores before and after the test (2-tailed), based on the small-scale t-test table. The t-test results show a significant difference, with a Sig. value (2-tailed) of 0.000 < 0.005.

Found an N-gain of 0.6171 from the small-scale N-gain test table, therefore it is in the middle range. After a pilot study with a smaller sample size, a larger study was conducted with 27 students using the same therapy and identical pre- and post-test questions. Here are the results of this extensive study.

Table 14. Large-scale normality test

Parameters	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Large Scale Pretest	0.112	27	0.200*	0.937	27	0.101
Large Scale Posttest	0.151	27	0.118	0.938	27	0.108

*. This is a lower bound of the true significance.

b. Lilliefors Significance Correction

Large-scale student learning outcome data follows a normal distribution, as seen in the large-scale normality test table, where the pretest normality test result is 0.101 and the posttest normality test result is 0.108.

Table 15. Large-scale T-test

Pair 1	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference		t	df	Sig. (2-tailed)
				Lower	Upper			
Large Scale Pretest - Large Scale Posttest	-29.222	10.237	1.970	-33.272	-25.173	-14.833	26	0.000

The large-scale t-test table displays a 2-tailed value of 0.000. A significant difference between the pretest and posttest findings is indicated by the data, with a Sig. (2-tailed) value of 0.000 < 0.005.

Table 16. Large-scale N-gain test

Descriptive Statistics					
	N	Min	Max	Mean	Std. Deviation
N_Gain	27	0.45	0.90	0.6461	.013353
Valid N (listwise)	27				

In the large-scale N-gain test table, the N-gain value of 0.6461 is known to be in the medium category. Because the number of respondents is less than 30, we analyzed the findings of the large-scale and small-scale research tests, namely the normality test using the Shapiro-Wilk type. Information is considered to follow a normal distribution if Sig. > 0.05 and is considered to deviate from the norm if Sig. <0.05. The distribution is known to be normal in both small-scale and large-scale tests. If Sig. (2-tailed) is less than 0.05 A significant difference between the results of science learning about the form of matter and its modifications can be concluded from the results of the small-scale and large-scale tests, where Sig. (2-tailed) <0.005. In addition, the medium-scale criteria were used in the small-scale and large-scale N-gain experiments (Nagy & Duma, 2023; Lackmann et al., 2021; Suminah et al., 2022). With an average increase in pre- and post-test scores, it is clear that the smart application maker media based on PBL content material and its revisions have a good impact (Gusmaweti et al., 2023; Hidayah & Mulyani, 2024; Rukoyah & Bektiningsih, 2024). The N-gain test also shows that the developed learning media meets the criteria with a score percentage of 61% and 64% indicating very effective.

Table 17. Results of the Teacher Response Questionnaire

Class	Result (%)
Teacher Class IV A	94

The results of the teacher's response to the Smart Apps Creator media, Forms of Substances and Their Changes, fall into the "very good" criteria with a few suggestions for the learning video to be enlarged in size in the application.

Table 18. Results of the Student Response Questionnaire

Class	Total	Result (%)
Class IV B	9 Students	100
Class IV A	27 Students	100

The results of student responses to the Smart Apps Creator media Forms of Matter and Their Changes from the results of the student response questionnaire. The results of the student responses were obtained from small-scale and large-scale trial activities. The results of the student response questionnaire obtained a percentage of 100% so that it entered the "very good" criteria in the feasibility percentage According to Abdullah et al. (2024); Luthfiah et al. (2024). This is in accordance with the opinion that says that the innovative science media developed can make learning more interesting (Lafifa & Rosana, 2023; Masfufah & Nurdyansyah, 2023). Based on student responses, it was stated that the Smart Apps Creator Forms of Substances and Their Changes media made students feel happy while learning and could understand the material more easily.

Evaluation

Evaluation is the last stage in the ADDIE model, aiming to ensure the effectiveness of the smart Apps creator-based science learning media based on student responses during implementation. Evaluation is carried out after each stage, according to the ADDIE chart. at the analysis stage, the researcher found that at SDN 1

Brobot, Purbalingga, the lecture method was still dominant and students needed a more active learning method and the school had started to implement the problem-based learning model, although the results were not optimal. In the design stage, the researcher replaced the learning video with a self-made video. In the development stage, the researcher added a barcode to the material page to facilitate access to the LKPD. In the implementation stage, the researcher replaced the papermode quiz which often had errors with a classic quiz, because during the small-scale product trial there were obstacles.

Conclusion

The research and discussion resulted in the conclusion that the material expert validator assessed the production of smart applications as very feasible, based on PBL material in the form of the form of matter and its changes. In addition, the media expert validator obtained a very feasible score of 93.3%. The media meets the medium level effectiveness standard with a value of 0.61 based on small-scale results and 0.64 based on large-scale results. Thus, it is clear that the learning outcomes of fourth grade elementary school students regarding the form of matter and its changes can be improved through the development of PBL-based smart app Creator learning media.

Acknowledgments
I would like to thank the supervisor who has been a very valuable resource during the writing of this work. The educator who specializes in validation who has facilitated the collection of resources. SD Negeri 1 Brobot for their support and approval during the research. The parents and family of the researcher who always provide prayers and moral support. Friends who have accompanied the researcher and provided words of support while working on the article.

Author Contributions
N. G. W., contributed in conducting research, product development, data analysis, and article preparation. D. W., contributed as a supervisor in research activities until article writing.

Funding
During the research process, the researcher used private funds and did not receive funds from external parties.

Conflicts of Interest
The author declares that he has no conflict of interest.

References

Abdullah, Herdini, & Putri, T. S. (2024). Validity and Practicality of E-Module Based on Phenomenon Based Learning Using Articulate Storyline on Material Colligative Properties of Solutions. *Jurnal Penelitian Pendidikan IPA*, *10*(2), 764–775. https://doi.org/10.29303/jppipa.v10i2.5837

Abdulrahaman, M. D., Faruk, N., Oloyede, A. A., Surajudeen-Bakinde, N. T., Olawoyin, L. A., Mejabi, O. V., Imam-Fulani, Y. O., Fahm, A. O., & Azeez, A. L. (2020). Multimedia tools in the teaching and learning processes: A systematic review. *Heliyon*, *6*(11), e05312. https://doi.org/10.1016/j.heliyon.2020.e05312

Afandi, M., Erdayani, R., Afandi, S. A., & Rafi, M. (2022). Analisis kebijakan otonomi pendidikan di Indonesia: Analysis of Education Autonomy Policy in Indonesia. *Journal of Government Science (GovSci) : Jurnal Ilmu Pemerintahan*, *3*(2), 85–99. https://doi.org/10.54144/govsci.v3i2.32

Ali, O., Murray, P. A., Momin, M., Dwivedi, Y. K., & Malik, T. (2024). The effects of artificial intelligence applications in educational settings: Challenges and strategies. *Technological Forecasting and Social Change*, *199*, 123076. https://doi.org/10.1016/j.techfore.2023.123076

Attard, C., & Holmes, K. (2022). An exploration of teacher and student perceptions of blended learning in four secondary mathematics classrooms. *Mathematics Education Research Journal*, *34*(4), 719–740. https://doi.org/10.1007/s13394-020-00359-2

Cai, J., Hwang, S., Melville, M., & Robison, V. (2023). Theory for Teaching and Teaching for Theory: Artifacts as Tangible Entities for Storing and Improving Professional Knowledge for Teaching. In A.-K. Praetorius & C. Y. Charalambous (Eds.), *Theorizing Teaching* (pp. 225–251). Springer International Publishing. https://doi.org/10.1007/978-3-031-25613-4_8

Chavda, K., & Nisarga, V. (2023). Single Parenting: Impact on Child's Development. *Journal of Indian Association for Child and Adolescent Mental Health*, *19*(1), 14–20. https://doi.org/10.1177/09731342231179017

Chukhray, N., Mrykhina, O., & Izonin, I. (2022). Holistic Approach to R&D Products' Evaluation for Commercialization under Open Innovations. *Journal of Open Innovation: Technology, Market, and Complexity*, *8*(1), 9. https://doi.org/10.3390/joitmc8010009

Deng, L., Wu, Y., Chen, L., & Peng, Z. (2024). 'Pursuing competencies' or 'pursuing scores'? High school teachers' perceptions and practices of competency-based education reform in China. *Teaching and Teacher Education*, *141*, 104510. https://doi.org/10.1016/j.tate.2024.104510

Falahat, M., Chong, S. C., & Liew, C. (2024). Navigating new product development: Uncovering factors and overcoming challenges for success. *Heliyon*, *10*(1), e23763. https://doi.org/10.1016/j.heliyon.2023.e23763

Garrido-Moreno, A., Martín-Rojas, R., & García-Morales, V. J. (2024). The key role of innovation and organizational resilience in improving business performance: A mixed-methods approach. *International Journal of Information Management*, *77*, 102777. https://doi.org/10.1016/j.ijinfomgt.2024.102777

González Hernández, W. (2022). The Teaching-Learning Process or the Teaching Process and the Learning Process. *Culture & Psychology*, 1354067X2210976. https://doi.org/10.1177/1354067X221097610

Gusmaweti, Rigel Prima Sari, & Enjoni. (2023). Application of Problem-Based Learning with Video Assistance to The Learning Outcomes of Science from Students in Class V Elementary. *Journal Of Digital Learning and Distance Education*, *1*(12), 387–394. https://doi.org/10.56778/jdlde.v1i12.107

Haleem, A., Javaid, M., Qadri, M. A., & Suman, R. (2022). Understanding the role of digital technologies in education: A review. *Sustainable Operations and Computers*, *3*, 275–285. https://doi.org/10.1016/j.susoc.2022.05.004

Hidayah, N., & Mulyani, P. K. (2024). The Development of Raya-In: Learning Media Based on Smart Apps Creator to Improve Primary School Social Science Learning. *Jurnal Penelitian Pendidikan IPA*, *10*(8), 5909–5918. https://doi.org/10.29303/jppipa.v10i8.9062

Hollister, B., Nair, P., Hill-Lindsay, S., & Chukoskie, L. (2022). Engagement in Online Learning: Student Attitudes and Behavior During COVID-19. *Frontiers in Education*, *7*, 851019. https://doi.org/10.3389/feduc.2022.851019

Holmes, W., & Tuomi, I. (2022). State of the art and practice in AI in education. *European Journal of Education*, *57*(4), 542–570. https://doi.org/10.1111/ejed.12533

Karatsiori, M. (2023). In the pursuit of "Quality Education": From ancient times to the digital era, can there be a consensus? *Cogent Education*, *10*(2), 2286817. https://doi.org/10.1080/2331186X.2023.2286817

Kintu, M. J., Zhu, C., & Kagambe, E. (2017). Blended learning effectiveness: The relationship between student characteristics, design features and outcomes. *International Journal of Educational Technology in Higher Education*, *14*(1), 7. https://doi.org/10.1186/s41239-017-0043-4

Lackmann, S., Léger, P.-M., Charland, P., Aubé, C., & Talbot, J. (2021). The Influence of Video Format on Engagement and Performance in Online Learning. *Brain Sciences*, *11*(2), 128. https://doi.org/10.3390/brainsci11020128

Lafifa, F., & Rosana, D. (2023). Development and Validation of Animation-Based Science Learning Media in the STEM-PBL Model to Improve Students Critical Thinking and Digital Literacy. *Jurnal Penelitian Pendidikan IPA*, *9*(9), 7445–7453. https://doi.org/10.29303/jppipa.v9i9.4448

Lavonen, J. (2020). Curriculum and Teacher Education Reforms in Finland That Support the Development of Competences for the Twenty-First Century. In F. M. Reimers (Ed.), *Audacious Education Purposes* (pp. 65–80). Springer International Publishing. https://doi.org/10.1007/978-3-030-41882-3_3

Luthfiah, Fauziah, N. E., Ani Nur Aeni, & Dety Amelia Karlina. (2024). Development of Stop Bullying E-Book as an Effort by PAI Teachers in Growing Student Anti-Bullying Knowledge and Attitudes. *Jurnal Elementaria Edukasia*, *7*(2), 2657–2674. https://doi.org/10.31949/jee.v7i2.9149

Masfufah, N. F., & Nurdyansyah, N. (2023). Imaginative Image-Based Learning Media Innovation to Improve Creativity and Psychomotor Abilities in Elementary Schools. *Journal of Innovation in Educational and Cultural Research*, *4*(3), 471–487. https://doi.org/10.46843/jiecr.v4i3.718

Mhlanga, D. (2024). Digital transformation of education, the limitations and prospects of introducing the fourth industrial revolution asynchronous online learning in emerging markets. *Discover Education*, *3*(1), 32. https://doi.org/10.1007/s44217-024-00115-9

Moses, R. N., & Mohamad, M. (2019). Challenges Faced by Students and Teachers on Writing Skills in ESL Contexts: A Literature Review. *Creative Education*, *10*(13), 3385–3391. https://doi.org/10.4236/ce.2019.1013260

Nagy, V., & Duma, L. (2023). Measuring efficiency and effectiveness of knowledge transfer in e-learning. *Heliyon*, *9*(7), e17502. https://doi.org/10.1016/j.heliyon.2023.e17502

Nur'ariyani, S., Jumyati, J., Yuliyanti, Y., Nulhakim, L., & Leksono, S. M. (2023). Scientific Approach to Learning Science in Elementary Schools. *Jurnal Penelitian Pendidikan IPA*, *9*(8), 6659–6666. https://doi.org/10.29303/jppipa.v9i8.3680

Puad, L. M. A. Z., & Ashton, K. (2023). A critical analysis of Indonesia's 2013 national curriculum: Tensions between global and local concerns. *The Curriculum Journal*, *34*(3), 521–535. https://doi.org/10.1002/curj.194

Putri, I., & Jumardi, J. (2023). Utilization of the Canva application on the Belajar.Id site as a learning media at SMK Bina Nusa Mandiri Jakarta. *Jurnal Inovasi*

Teknologi Pendidikan, *10*(4), 344–352. https://doi.org/10.21831/jitp.v10i4.63299

Rukoyah, S., & Bektiningsih, K. (2024). Development of Interactive Learning Media Based on Smart Apps Creator to Enhance Elementary School Students' Science Learning Outcomes. *Jurnal Penelitian Pendidikan IPA*, *10*(10), 8127–8135. https://doi.org/10.29303/jppipa.v10i10.8046

Silaban, R., Br Girsang, O. A., Manalu, R. T., Sitorus, M., Tarigan, S., & Alexander, I. (2024). Analysis of Teachers and Student Responses to Android-based Chemical Bonding Learning Media Using Smart Apps Creator Program. *Proceedings of the 5th International Conference on Innovation in Education, Science, and Culture, ICIESC 2023, 24 October 2023, Medan, Indonesia*. https://doi.org/10.4108/eai.24-10-2023.2342270

Stevens, J. R., Herrick, J. S., Wolff, R. K., & Slattery, M. L. (2018). Power in pairs: Assessing the statistical value of paired samples in tests for differential expression. *BMC Genomics*, *19*(1), 953. https://doi.org/10.1186/s12864-018-5236-2

Suminah, S., Suwarto, S., Sugihardjo, S., Anantanyu, S., & Padmaningrum, D. (2022). Determinants of micro, small, and medium-scale enterprise performers' income during the Covid-19 pandemic era. *Heliyon*, *8*(7), e09875. https://doi.org/10.1016/j.heliyon.2022.e09875

Tsehay, S., Belay, M., & Seifu, A. (2024). Challenges in constructivist teaching: Insights from social studies teachers in middle-level schools, West Gojjam Zone, Ethiopia. *Cogent Education*, *11*(1), 2372198. https://doi.org/10.1080/2331186X.2024.2372198

Wahlström, N. (2023). Curriculum policy, teaching, and knowledge orientations. *Teachers and Teaching*, *29*(3), 259–275. https://doi.org/10.1080/13540602.2022.2159364

Wang, L., Wang, X., Liang, N., & Xiao, M. (2010). How to Make Highly Rational Use of Modern Educational Technologies. *Intelligent Information Management*, *02*(11), 647–651. https://doi.org/10.4236/iim.2010.211074

Wang, S., Wang, F., Zhu, Z., Wang, J., Tran, T., & Du, Z. (2024). Artificial intelligence in education: A systematic literature review. *Expert Systems with Applications*, *252*, 124167. https://doi.org/10.1016/j.eswa.2024.124167

Wang, Y., Tang, Y., & Ye, Z.-S. (2022). Paired or Partially Paired Two-sample Tests With Unordered Samples. *Journal of the Royal Statistical Society Series B: Statistical Methodology*, *84*(4), 1503–1525. https://doi.org/10.1111/rssb.12541

Zamiri, M., & Esmaeili, A. (2024). Methods and Technologies for Supporting Knowledge Sharing within Learning Communities: A Systematic Literature Review. *Administrative Sciences*, *14*(1), 17. https://doi.org/10.3390/admsci14010017