PjBL-STEM-based Animal & Plants Metamorphosis Multimedia Innovation: Improving Students' Critical Thinking Skills in Elementary School

Aan Widiyono[*)], Syailin Nichla Choirin Attalina, Erna Zumrotun, Lola Aulia Putri, Lulu' lu'luatil Masturoh

Universitas Islam Nahdlatul Ulama Jepara, Indonesia

Abstract

This research develops *PjBL-STEM-based Animal & Plants Metamorphosis* interactive multimedia products in IPAS subjects with the topic of the life cycle of living things. The purpose of the development is to help students learn independently anytime and anywhere without an internet connection, as well as to improve critical thinking skills. The research design uses the ADDIE model development for the research method using pretest-posttest analysis through a test instrument whose results are continued in a paired t-test to evaluate the improvement of learning outcomes. The product validation process was carried out by subject matter experts, media experts, and learning design experts, all of whom were categorised as very good. Testing showed that the app is relevant to the learning outcomes and supports student-centred active learning. This application proved effective in improving students' understanding and critical thinking skills. The attractive appearance and interactive animations on the multimedia contribute to motivating students to learn more effectively. Although this application only focuses on IPAS material for phase B, the results show that this product is feasible to use and has a positive impact on the learning process.

INTRODUCTION

Education in the 21st century requires students to have skills that are adaptive to global developments. In an era full of technological and information advances, critical thinking, problem-solving, creativity, and collaboration are very important skills. *The Organisation for Economic Co-operation and Development* (OECD) report confirms that the development of these skills is a key pillar in improving student competencies in various countries, including Indonesia (OECD, 2019). Evaluation through the *Program for International Student Assessment* (PISA) shows that Indonesian students' science and mathematics literacy skills are still below the international average. These results reflect major challenges in Indonesia's education system that require learning innovations that are more relevant to real conditions. In addition to PISA, other studies such as the Trends in International Mathematics and Science Study (TIMSS) and the *Progress in International Reading Literacy Study* (PIRLS) also show similar results (Van Staden et al., 2020). Based on TIMSS data, Indonesian students' achievements in science and mathematics are still lagging behind those of neighbouring countries. PIRLS, which assesses reading literacy skills in grade IV elementary school students, also shows that the literacy level of Indonesian students still requires serious attention. This condition raises an urgent need for

Education in Indonesia to increase access to quality and innovative Education, especially in the fields of science and technology (C. Faizatul et al., 2024; Fakhri, 2023)

The Science, Technology, Engineering, and Mathematics (STEM) approach is one of the reliable solutions to this challenge. STEM-based Education emphasises the integration of various disciplines that play an important role in shaping students' skills in the 21st century (Bybee, 2010; Waters & Orange, 2022). One of the learning models that support this approach is *Project-Based Learning (PjBL)*, which provides space for students to learn independently and be directly involved in solving real problems (Larmer et al., 2015; Mergendoller et al., 2006). Thus, the *PjBL-STEM* approach not only aims to teach knowledge but also to develop critical thinking, problem-solving, and collaboration skills among students (Laboy-Rush, 2011). In the context of science learning in elementary schools, the application of this method becomes very relevant, especially for materials that demand in-depth understanding, such as animal and plant metamorphosis. Science is one of the important subjects that introduces students to basic concepts about natural phenomena (Danial et al., 2021). However, science learning in elementary schools is often constrained by methods of delivering material that tend to be abstract and do not involve students actively. In preliminary studies at SDN Kalianyar 1, the results of observations show that students have difficulty understanding the concept of animal and plant metamorphosis. They tend to just memorise the metamorphosis cycle without being able to apply it in real life, which shows low critical thinking skills.

This problem further emphasises the need for innovation in learning media that can help students understand science material better. One innovation that can be developed is project-based learning media with a STEM approach (Laboy-Rush, 2011). One of the innovations that can be developed is project-based learning media with a STEM approach, namely *Multimedia Animal & Plants Metamorphosis*. This media is designed to facilitate students' critical thinking skills through interactive learning that combines simulation, animation, and collaborative projects. By utilising multimedia technology, students can learn in a more enjoyable and meaningful way because they can visualise the process of animal and plant metamorphosis more clearly and understand the concept more deeply (Asrial et al., 2019; Ferlianti et al., 2022). The use of *PjBL-STEM-based Animal & Plants Metamorphosis Multimedia* also provides a more contextualised learning experience. Students not only receive information passively but also actively participate in the learning process. They are involved in real projects that challenge their analytical and critical thinking skills, which are essential to face challenges in the global era. In addition, this media is able to accommodate various learning styles of students, thus increasing their learning motivation and engagement in science learning (Haryanto et al., 2022; Paul & Elder, 2006; Shamboul, 2022).

This study aims to improve students' critical thinking skills through the development and effectiveness testing of *PjBL-STEM-based Animal & Plants Metamorphosis Multimedia* on animal and plant metamorphosis material. The development of this media is expected to be an innovative solution to overcome the challenges faced in science learning in elementary schools, especially at SDN Kalianyar 1. This research will also evaluate how the media can be applied effectively in a more interactive learning context and relevant to students' daily lives. Through this study, it is expected that science learning in the 21st century still requires media innovation that can help students develop critical thinking skills. Through *PjBL-STEM-based Animal & Plants Metamorphosis* media, students are expected to more easily understand the concept of animal and plant metamorphosis and be able to apply it in the context of real life. Thus, the use of interactive learning media such as *Animal & Plants Metamorphosis Multimedia* will not only improve students' understanding of science materials but also prepare them to face more complex future challenges.

METHODS

This study aims to develop and test the effectiveness of multimedia metamorphosis of animals and plants based on Project-Based Learning (PjBL) integrated with the STEM (Science, Technology, Engineering, and Mathematics) approach in improving critical thinking skills of third-grade students of SDN Kalianyar 1. The development model used is ADDIE (Analysis, Design, Development, Implementation, Evaluation) (Branch, 2009; Molenda, 2003). The analysis stage was conducted to identify learning needs, such as student characteristics, limitations of existing learning media, and relevant learning objectives. Furthermore, at the design stage, a multimedia prototype was designed that integrates interactive animations, digital simulations, and game-based quizzes to support students' understanding of animal and plant metamorphosis. The prototype was validated by six experts, including material, learning design, and learning media experts. In the development stage, the multimedia was finalised based on the input from the experts and then implemented in learning at SDN Kalianyar 1. The implementation stage involved a pilot test conducted on 12 third-grade students, which was carried out in several cycles to ensure the multimedia was practical and effective in the classroom context. Finally, the evaluation stage was conducted by measuring the effectiveness of the multimedia using the pretest-posttest method. The research instruments were questions designed to measure students' critical thinking skills based on indicators of analysis, evaluation, and synthesis of information. Data was collected using a questionnaire with a 5-point Likert scale to assess the validity and quality of the product from the expert's perspective to find out the meaning of the percentage of the score obtained; it can be seen in Table 1. The effectiveness test results were analysed using the T-test with significant parameters (p-value <0.05) to see the difference in pretest and post-test results.

Table 1. Conversion of Achievement Level with Scale 5

No.	Achievement Rate (%)	Qualification	Description
1.	90-100%	Very good	There is no need to revise
2.	75-89%	Good	Slightly revised
3.	65-74%	Good enough	Revised to taste
4.	55-64%	Less Good	Many things were revised
5.	1-54%	Very Poor	Repeated making of the product
Total			

RESULTS & DISCUSSION

Results

Product development in this study used the ADDIE development model. This ADDIE development model consists of 5 stages. The first stage is the analysis stage, the second stage is the design stage, the third stage is the development stage, the fourth stage is the implementation stage, and the fifth stage is the evaluation stage.

Stage 1 Analysis

At the analysis stage, a learning needs analysis is carried out, which aims to find out the problems in learning at school and find solutions to help teachers and schools so that there is an improvement in the quality of learning. The analysis activities carried out

include analysing learning outcomes and learning objectives required by students, analysing facilities and infrastructure, and analysing materials. In the analysis of facilities and infrastructure, it is known that students at SDN Kalianyar 1 Demak, especially grade III students, have a projector installed and a Chromebook that students can utilise. The availability of learning resources for IPAS books is still minimal compared to other books. At the material analysis stage, the material chosen for the *PjBL-STEM-based Animal & Plants Metamorphosis* Multimedia is Chapter 2 on Recognizing Cycles in Living Things. The material discussed includes 1) Recognizing Cycles in Living Things, 2) the Life Cycle of Animals, and 3) Metamorphosis, Changes in the Form of Living Things. The determination of learning outcomes and learning objectives used in learning media is presented in Table 2.

Table 2. Learning Outcomes and Learning Objectives

No.	Learning Outcomes	Learning Objectives
1	Able to explain the stages of the life cycle of living things	Understand the stages of the life cycle of living things
2	Able to compare life cycles in humans, animals, and plants1	Comparing the life cycles of humans, animals, and plants.
3	Able to make simulations using charts or simple tools about animal life cycles	Using simple tools to visualise the animal life cycle.

Stage 2 Design

The second stage is design/design. After analysing information about the material, the next activity is the *design* or *design of the* product used in the development. In the design stage, the things that are done are determining *hardware* and *software*, making a design of interactive multimedia (*storyboard* and *flowchart)*, designing interactive multimedia components using the *Smart Application Creator application,* compiling learning menus displayed on *PjBL-STEM-based Animal & Plants Metamorphosis* multimedia, such as materials, LKPD, learning videos, and assessment instruments,

Stage 3 Development

The third stage is development. At the *development* stage, development is carried out on the multimedia *Animal & Plants Metamorphosis* based on *PjBL-STEM* based on Android applications in Chapter 2 on Knowing Cycles in Living Things based on previous designs, which include making illustrations using the *Smart Application Creator* application*, Adobe Animate*, *editing* application support components that have been prepared starting to be combined in accordance with the *storyboard* arrangement that has been designed using *Adobe Animate*, adding *action scripts* to the application using the *Adobe Animate* application which aims to control the program that has been created. The results of the development of this learning application media product can be understood in the workings of the following application:

1. Open App
   Ensure that the app is installed on your device. Launch the app by pressing the app icon on the device screen.
2. Starting the Learning
   On the main screen, you will see the title "Metamorphosis in Animals" with attractive illustrations, and press the START button to start the learning material.

Figure 1. Main view and learning menu

3. Select Main Menu

On the main page, you will see several menu options. Select one according to your needs:

a. Learning Materials: To access available teaching materials.
b. Evaluation: To do practice questions related to the material.
c. LKPD: To fill in the Learner Worksheet (LKPD).
d. Learning Videos: To watch videos related to the material being studied.
e. Learning Objectives: To see your learning outcomes or progress.

4. Learning Materials

If you select the "Learning Materials" menu, you will be directed to a page with a list of materials. Click on the material you want to learn.

Figure 2: Display on one of the material sections

5. Evaluation: After studying the material, you can proceed to "Evaluation."
    LKPD: On the menu "LKPD," you can fill in the worksheets that are given. Follow the guidelines in the app to complete them.
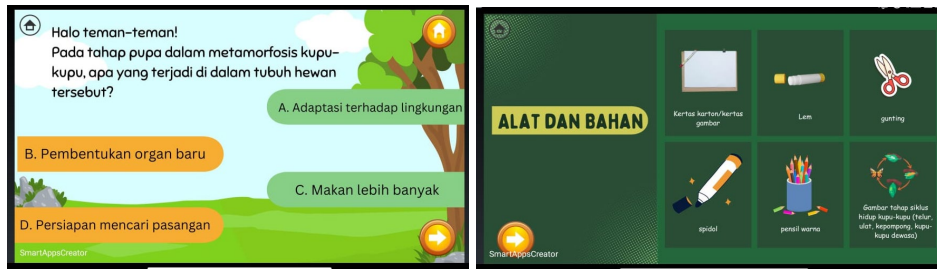

Figure 3. Display of one of the parts of the Evaluation and LKPD

6. Learning Video
    In the "Learning Videos" menu, select the video you wish to watch. There is no need to make sure your device is connected to the internet, as the videos are downloaded offline.

Figure 4. Display of learning objectives and one part of the learning video

7. Learning Objectives
    Use this menu to view learning objectives.
8. Back Navigation
    If you want to return to the main menu, press the "Home" icon in the top left corner of the screen.

PjBL-STEM-based Animal & Plants Metamorphosis Multimedia is a modern digital solution for learning the life cycle of living things. With interactive features, visual simulations, and engaging quizzes, this application makes learning more fun while deepening students' understanding of the life cycle of living things.

Stage 4 Implementation

The fourth stage in this research is implementation. At this stage, the application of application media has been made to be validated by experts and trials on students in order to achieve learning objectives and to find out students' responses to the use of learning media. The more detailed results of this implementation stage can be seen in Table 3.

Table 3. Percentage of Validity Results of Learning Application Development

Test Subject	Validation Result (%)
Subject Content Expert	98
Learning Media Expert	92
Learning Design Expert	88
Individual Trial	90
Small Group Trial	86

Stage 5 Evaluation

The fifth or final stage of the ADDIE development model is the evaluation stage. At this stage, improvements are made to the media based on *reviews* from experts and students as test subjects so that the application media that has been made can be said to be feasible or effective as a learning media that students can use.

Table 3. Descriptive statistical test results

	Pretest	**Posttest**
N	12	12
Missing	0	0
Mean	69.6	82.8
Median	70.0	82.5
Standard deviation	4.12	5.14
Minimum	60	74
Maximum	75	91
Shapiro-Wilk W	0.918	0.976

The results showed that learning with *PjBL-STEM-based Animal & Plants Metamorphosis* multimedia significantly improved students' critical thinking skills, with an average pretest of 69.6 and posttest increasing to 82.8. The slightly increased standard deviation indicates a greater variation in student performance on the posttest, but overall, all students experienced an increase in scores. The Shapiro-Wilk normality test showed that the pretest and posttest data were normally distributed ($p > 0.05$), so the difference in critical thinking skills scores can be considered significant and consistent. This increase in value indicates that the use of *PjBL-STEM-based Animal & Plants Metamorphosis* multimedia is effective in improving student learning outcomes.

The results of the pretest and posttest scores in the use of *PjBL-STEM-based Animal & Plants Metamorphosis* multimedia can be seen through the following graph:
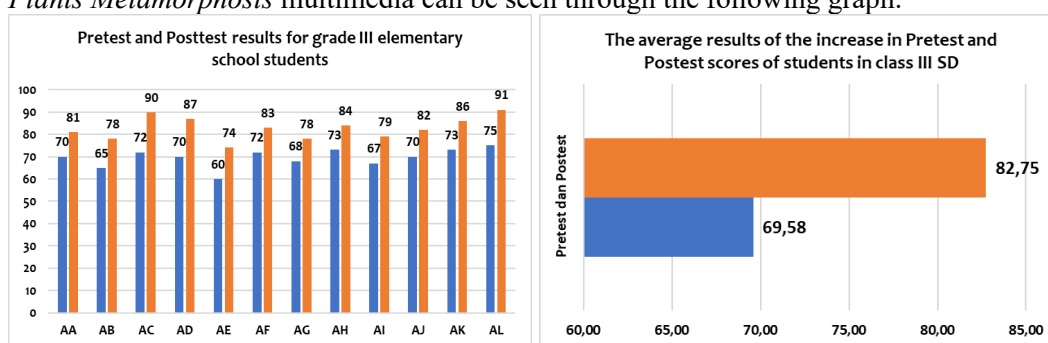

Figure 5. pretest and posttest scores and average increase

Table 4. Paired Samples T-Test results

			statistic	**df**	**p**
Pretest	Posttest	Student's t	-17.6	11.0	< .001

Note. $H_a \mu$ Measure 1 - Measure 2 $\neq 0$

The paired t-test results show that there is a significant difference between students' pretest and post-test scores. The Student's t value of -17.6 with degrees of freedom (df) 11 indicates that student learning outcomes after using *PjBL-STEM-based Animal & Plants Metamorphosis* multimedia are much better than before learning. The p-value, which is smaller than 0.001 (p < 0.001), indicates that this difference is highly statistically significant, so it can be concluded that the learning carried out has had a significant positive impact on improving student scores. Thus, the alternative hypothesis (H_a: μ Measure 1 - Measure 2 ≠ 0) is accepted, which means there is a real difference between the pretest and posttest scores.

Discussion

The *PjBL-STEM-based Animal & Plants Metamorphosis* Multimedia product in the IPAS subject with the topic of the life cycle of living things has been developed with an average percentage score of 91%, which is categorised as very good. This value is obtained through various processes and stages that show that this application is suitable for use in learning. The development of this multimedia aims to enable students to learn and understand the topic of the life cycle of living things independently, anytime and anywhere, even without an internet connection, so that students can interact directly with the material. The use of this application is expected to increase learning efficiency and motivation and facilitate students' active and experimental learning with a student-centred approach (Guna et al., 2019; Husein & Herayanti, 2015; Siti Muyaroah; Mega Fajartia, 2017; Tafona Talizaro, 2018). The results of the validity test by subject content experts obtained a score of 98%, which was categorised as very good. This assessment is based on the suitability of the material displayed in the application with the topic of the life cycle of living things, as well as its relevance to learning outcomes and learning objectives. Before determining the media to be developed, teachers need to identify several things, such as learning objectives in each phase, as well as the validity of the material so that its truth and validity can be tested (Fanny, 2018). Thus, the media development process will be in accordance with the established learning rules.

In the media expert test, this multimedia product scored 92% with very good qualifications, seen from the aspects of practicality and appearance. In terms of practicality, this application can be used in various places and times so that students can learn flexibly. This media is also developed to be more interesting through animation. However, the display aspect emphasises the clarity of audio, text, image selection, and the right composition and colour combination, which supports the success of learning (Nurrita, 2018; Trianawati et al., 2020). An attractive appearance can make it easier for students to remember lessons with the cognitive influence provided by colour (Fauziyyah, 2019; Jatmika, 2005). Therefore, this learning media is proven to increase student learning motivation, which has a positive impact on learning outcomes (Dwiqi et al., 2020). The learning design expert test results showed a score of 88%, with good qualifications. This assessment includes the suitability of learning objectives and outcomes, as well as strategies that involve providing opportunities for students to learn independently with clarity of learning instructions based on the *PjBL-STEM* model. The evaluation aspect includes the availability of evaluations that are in accordance with the material. To improve the connection between materials, better learning strategies are needed to motivate students to learn. A good evaluation will improve the quality of learning and help teachers plan effective learning strategies (Magdalena et al., 2020; Nida et al., 2020). Validation and trial of interactive multimedia based on this Android application obtained very good results and responses from experts and students as test subjects. This media was developed based on the needs of the field, with an attractive appearance and flexibility to use at any time without

requiring an internet connection. The use of this application is proven to help students understand the material better (Myori et al., 2019).

Based on the analysis, learning with *PjBL-STEM*-based *Animal & Plants Metamorphosis* multimedia is proven to improve students' critical thinking skills significantly. The average pretest score recorded at 69.6 indicates that students had sufficient understanding before learning, but after applying this method, the average posttest score increased to 82.8. This increase, although accompanied by a slightly higher standard deviation on the posttest, indicates that there was variation in student performance, with some students making greater progress than others. The normality test showing $p > 0.05$ confirmed that the distribution of the pretest and posttest data was normal, making it valid for further statistical analysis. The paired t-test results with a t value of -17.6 and $p < 0.001$ confirmed that the difference between the pretest and posttest was highly statistically significant. In other words, students' learning outcomes after taking part in learning with this multimedia showed a significant increase, supporting the hypothesis that the *PjBL-STEM* approach is effective in improving learning outcomes.

The improvement of students' critical thinking skills through *PjBL-STEM*-based learning and animal and plant metamorphosis multimedia occurs because this approach encourages students' active involvement in the learning process. Each step of *PjBL-STEM*, such as problem identification, solution design, implementation, and reflection, directly improves students' analysis, evaluation, and synthesis skills. The use of interactive and engaging multimedia supports concept understanding with effective visualisation, thus strengthening the learning impact. Data analysis showed a significant difference between the pretest and posttest results, with the mean score increasing from 69.6 to 82.8, and the T-test results showed statistical significance ($p < 0.001$). This confirms that the *PjBL-STEM* approach is more dominant in encouraging the improvement of critical thinking skills, while multimedia serves as a support that strengthens the learning process. The combination of the two proves the effectiveness of this method in improving the quality of 21st-century learning.

Research Rizki & Febtiningsih (2022) mentioned that this animated multimedia received a very good category score in the aspects of material validity, appearance, and graphic programming. This media was developed by displaying animations, text, images, and more complete practice questions (Arif, 2023; Widiyono et al., 2023). In addition, interactive animation is very important in improving the quality of student learning (Amrina et al., 2021; Rosdiana et al., 2024). The limitation of this research is that this interactive multimedia only contains IPAS subject matter, which is recommended for use in phase B. The implications of this research make the learning process more interesting, interactive, and fun for students, and it has proven to be feasible to use in learning with excellent trial results. This application requires devices such as mobile phones, computers, or emulators to support its use. The use of this PjBL-STEM-based multimedia has positive implications for the learning process, making it more interesting, interactive and fun. With excellent trial results, this media is feasible to use to support 21st-century learning. However, for further development, it is suggested that the content be extended to other materials and that further research be conducted to explore its applicability to different phases of education. Overall, the combination of the PjBL-STEM approach and the use of interactive multimedia proved its effectiveness in improving the quality of education, especially in developing students' critical thinking skills.

CONCLUSION

Based on the results of the study, the *PjBL-STEM*-based *Animal & Plants Metamorphosis* multimedia product in IPAS subjects proved to be very feasible to use in learning, with an average validity score of 91%. This application helps students learn independently, flexibly, and without an internet connection and increases motivation and learning efficiency. Subject matter expert validity test scores of 98%, media expert 92%, and learning design expert 88% confirmed the app's feasibility and practicality. Student testing showed a significant increase in critical thinking skills, where the average posttest score increased from 69.6 to 82.8 with significant statistical test results. Although there are variations in student performance, this multimedia is effective in improving critical thinking skills, especially with the attractive animation display and complete material evaluation. However, the limitation is that the material is limited to IPAS phase B. Overall, this application has a positive impact on 21st-century learning and deserves to be used more widely in Education.

CONFLICT OF INTEREST

The authors declare no conflict of interest from the substance of the research activities to the results obtained. The results of this study contribute to improving the learning process in elementary schools.

ACKNOWLEDGEMENT

REFERENCE

Fakhri, A. (2023). Kurikulum merdeka dan pengembangan perangkat pembelajaran: menjawab tantangan sosial dalam meningkatkan keterampilan abad 21. *Conference of Elementary Studies*, 32–40.

Amrina, N., Gazali, A., Mudinillah, G., Agustina, A., & Luksfinanto, A. (2021). Utility of the Smart App Creator Application as an Arabic Learning Media. *Izdihar : Journal of Arabic Language Teaching, Linguistics, and Literature*, *4*(3), 319–334. https://doi.org/10.22219/jiz.v4i3.176886

Arif, N. (2023). Pengembangan Smart App Creator untuk Meningkatkan Literasi Peserta Didik pada Mata Pelajaran IPS di Sekolah Dasar. *Jurnal Didaktika Pendidikan Dasar*, *7*(3), 809–828. https://doi.org/10.26811/didaktika.v7i3.697

Asrial, Syahrial, Kurniawan, D. A., Chan, F., Septianingsih, R., & Perdana, R. (2019). Multimedia innovation 4.0 in education: E-module ethnoconstructivism. *Universal Journal of Educational Research*, *7*(10), 2098–2107. https://doi.org/10.13189/ujer.2019.071007

Branch, R. M. (2009). *Instructional design: The ADDIE approach* (Vol. 722). Springer Science & Business Media.

Bybee, R. W. (2010). What is STEM education? *Science*, *329*(5995), 996. https://doi.org/DOI:10.1126/science.1194998

Danial, M., Yunus, M., Syamsir, M., & Rahmania. (2021). A Development of IPA (Natural Sciences) Learning Tools Based on Investigative Approach in Empowering Students' Higher-Order Thinking Skills and Concept Mastery in Junior High School. *2nd Workshop on Engineering, Education, Applied Sciences and Technology, WEAST 2020*, *1899*(1). https://doi.org/10.1088/1742-6596/1899/1/012143

Dwiqi, G. C. S., Sudatha, I. G. W., & Sukmana, A. I. W. I. Y. (2020). Pengembangan multimedia pembelajaran interaktif mata pelajaran IPA untuk siswa SD kelas V. *Jurnal Edutech Undiksha*, *8*(2), 33–48. https://doi.org/https://doi.org/10.23887/jeu.v8i2.28934

Faizatul, C., Ina Nur, A. I., Irma Amira, P., & Kinanti Cindy, E. (2024). Literatur review: Urgensi keterampilan abad 21 pada peserta didik. *Jurnal Pembelajaran, Bimbingan, Dan Pengelolaan Pendidikan*, *4*(4), 2024. https://doi.org/10.17977/um065.v4.i4.2024.1

Fanny, A. M. (2018). Paradigma Kreativitas Pembuatan Multimedia Pembelajaran IPS di SD. *Buana Pendidikan: Jurnal Fakultas Keguruan Dan Ilmu Pendidikan Unipa Surabaya*, *13*(23), 1–9. https://doi.org/https://doi.org/10.36456/bp.vol13.no23.a1582

Ferlianti, S., Rusdiana, D., Suwarma, I. R., & Nurbani, A. R. (2022). Pengembangan Multimedia Pembelajaran Interaktif SAC pada Materi Tekanan Hidrostatis. *Jurnal Pendidikan Indonesia*, *3*(01), 13–24.

Guna, I. M. D., Agung, A. A. G., & Pudjawan, K. (2019). Game education mata pelajaran matematika untuk siswa kelas iv sd negeri 1 paket agung. *Jurnal EDUTECH Universitas Pendidikan Ganesha*, *7*(2), 14–23. https://doi.org/http://dx.doi.org/10.23887/jeu.v7i2.21669

Haryanto, H., Ghufron, A., Suyantiningsih, S., & Kumala, F. N. (2022). The Correlation between Digital Literacy and Parents' Roles towards Elementary School Students' Critical Thinking. *Cypriot Journal of Educational Sciences*, *17*(3), 828–839. https://doi.org/https://eric.ed.gov/?id=EJ1336093

Husein, S., & Herayanti, L. (2015). Pengaruh penggunaan multimedia interaktif terhadap penguasaan konsep dan keterampilan berpikir kritis siswa pada materi suhu dan kalor. *Jurnal Pendidikan Fisika Dan Teknologi*, *I*(3), 2407–6902. https://doi.org/https://doi.org/10.29303/jpft.v1i3.262

Laboy-Rush, D. (2011). *Integrated STEM education through project-based learning*.

Larmer, J., Mergendoller, J., & Boss, S. (2015). *Setting the standard for project-based learning*. ASCD.

Magdalena, I., Fauzi, H. N., & Putri, R. (2020). Pentingnya evaluasi dalam pembelajaran dan akibat memanipulasinya. *Jurnal Pendidikan Dan Sains*, *2*(2), 244–257. https://doi.org/https://doi.org/10.36088/bintang.v2i2.986

Mergendoller, J. R., Markham, T., Ravitz, J., & Larmer, J. (2006). Pervasive Management of Project Based Learning: Teachers as Guides and Facilitators. In *Handbook of classroom management: Research, practice, and contemporary issues.* (pp. 583–615). Lawrence Erlbaum Associates Publishers.

Molenda, M. (2003). In Search of the Elusive ADDIE Model. *Performance Improvement*, *42 (5)*, 34–37. http://www.nwlink.com/~donclark/hrd/sat1.html#model.

Myori, D. E., Chaniago, K., Hidayat, R., Eliza, F., & Fadli, R. (2019). Peningkatan kompetensi guru dalam penguasaan teknologi informasi dan komunikasi melalui pelatihan pengembangan media pembelajaran berbasis android. *JTEV (Jurnal Teknik*

Elektro Dan Vokasional), *5*(2), 102–109. https://doi.org/https://doi.org/10.24036/jtev.v5i2.106832.

Nida, D. M. A. A., Parmiti, D. P., & Sukmana, A. I. W. I. Y. (2020). Pengembangan media kartu bergambar berorientasi pendidikan karakter pada mata pelajaran bahasa bali. *Jurnal Edutech Undiksha*, *8*(1), 16–31. https://doi.org/https://doi.org/10.23887/jeu.v8i1.25393

Nurrita, T. (2018). Pengembangan media pembelajaran untuk meningkatkan hasil belajar siswa. *Jurnal Misykat*, *3*(1), 171–187. https://doi.org/http://dx.doi.org/10.33511/misykat.v3n1.171

OECD, O. (2019). *Social Impact Investment 2019 The Impact Imperative for Sustainable Development*. OECD.

Paul, R., & Elder, L. (2006). *Critical thinking: Learn the tools the best thinkers use*. Pearson Prentice Hall.

Rizki, S., & Febtiningsih, P. (2022). ELT-Lectura: Studies and Perspectives in English Language Development of Learning Media Using Smart Apps Creator on "Introducing Oneself and Others." *ELT-Lectura*, *9*(2).

Rosdiana, A., Widiyono, A., Nisah, N., Al Azizi, M. N., & Putri, L. A. (2024). Enhancing Teachers' Professional Development By Implementing Smart Apps Creator (SAC). *KUAT: Keuangan Umum Dan Akuntansi Terapan*, *6*(1), 9–17. https://doi.org/https://doi.org/10.31092/kuat.v6i1.2590

Shamboul, H. A. E. (2022). The Importance of Critical Thinking on Teaching Learning Process. *Open Journal of Social Sciences*, *10*(01), 29–35. https://doi.org/10.4236/jss.2022.101003

Siti Muyaroah; Mega Fajartia. (2017). Pengembangan media pembelajaran berbasis android dengan menggunakan aplikasi adobe flash cs 6 pada mata pelajaran biologi. *Innovative Journal of Curriculum and Educational Technology IJCET*, *6*(2). https://doi.org/https://doi.org/10.35438/e.v8i1.221

Tafona Talizaro. (2018). Peranan media pembelajaran dalam meningkatkan minat belajar mahasiswa. *Jurnal Komunikasi Pendidikan*, *2*(2). https://doi.org/https://doi.org/10.32585/jkp.v2i2.113

Trianawati, I. G. A. K., Ardana, I. K., & Abadi, I. B. G. S. (2020). Pengaruh Model Discovery Learning Berbantuan Media Animasi Terhadap Kompetensi Pengetahuan IPA. *International Journal of Elementary Education*, *4*(1), 73–82. https://doi.org/https://doi.org/10.23887/ijee.v4i1.24337

Van Staden, S., Graham, M. A., & Harvey, J. C. (2020). An analysis of TIMSS 2015 science reading demands. *Perspectives in Education*, *38*, 285–302. https://doi.org/https://doi.org/10.38140/pie.v38i2.4338

Waters, C. C., & Orange, A. (2022). STEM-driven school culture: Pillars of a transformative STEM approach. *Journal of Pedagogical Research*, *6*(2), 72–90. https://doi.org/10.33902/JPR.202213550

Widiyono, A., Zumrotun, E., Wahyuningtyas, I. N., & Ariyanti, D. P. (2023). Penerapan Model PjBL-STEM melalui Smart Apps Creator (SAC) terhadap keterampilan Berpikir Kritis Siswa di Sekolah Dasar. *DWIJA CENDEKIA: Jurnal Riset Pedagogik*, *7*(3). https://doi.org/https://doi.org/10.20961/jdc.v7i3.79918