

# The Development of PBL-Based Respiratory App Learning Media on Human Respiratory System Material to Improve Critical Thinking Skills of Grade 11<sup>th</sup> Students

Hosniyah<sup>1\*</sup>, Evy Yulianti<sup>1</sup>, Ahmad Kamal Sudrajat<sup>1</sup>, Hairiyah<sup>2</sup>

<sup>1</sup> Department of Biology Education, Faculty of Math and Sciences, Yogyakarta State University, Yogyakarta, Indonesia.

<sup>2</sup> Department of Education, Faculty of Tarbiyah and Teacher Education, Alma Ata University, Yogyakarta, Indonesia.

Received: April 5, 2023

Revised: June 4, 2023

Accepted: August 25, 2023

Published: August 31, 2023

Corresponding Author:

Hosniyah

[hosniyahhs@gmail.com](mailto:hosniyahhs@gmail.com)

DOI: [10.29303/jppipa.v9i8.3587](https://doi.org/10.29303/jppipa.v9i8.3587)

© 2023 The Authors. This open access article is distributed under a (CC-BY License)



**Abstract:** This research aims to develop a PBL-based Respiratory App learning media on human respiratory system material, and to assess the feasibility, practicability, and effectiveness of the PBL-based Respiratory App learning media to improve critical thinking skills of class XI students at SMAN 6 Yogyakarta. This research used the ADDIE model developed by Dick and Carry. ANOVA test was used to analyze data of critical thinking skills. The results of the feasibility of learning media from material expert lecturers obtained an average score of 3.0 with a decent category. Media feasibility assessment conducted by media expert lecturers obtained an average score of 3.8 with a very feasible category and practicability assessment from biology subject teachers obtained an average score of 3.5 with a very practical category. The results of the small group trial obtained an average score of 3.3 with a practical category. Field trials using quasi-experiments showed sig 0.00, and the experimental class's critical thinking skills significantly different from the control class. The N-gain score showed the experimental class value is higher than the control class. Based on the research results, it will be concluded as follows: 1) PBL-based Respiratory App learning media was feasible and practicable for use in the learning process. 2) PBL-based Respiratory App learning media effectively improves students' critical thinking

**Keywords:** Critical thinking skills; Human respiratory system; Learning media, Problem based learning; Respiratory app

## Introduction

Indonesia is currently entering an era of globalization marked by changes in all sectors, one of which is technology. The advancement of the technology sector is accompanied by socio-economic and cultural changes. The development of technology affects various fields of life, including education. Education in the 21st century allows technology-based learning to grow rapidly. The development of technology has led to various developments in the field of education. This phenomenon requires teachers to be able to master and adapt to new technologies, so that they can answer educational challenges, because to face this era there is a

need for creative, innovative, and competitive education (Lase, 2020). In addition to the challenge of mastering technology for teachers, educational challenges in the 21st century or better known as the 4.0 era, require participants to master 4C skills, one of which is Critical thinking Skill. Critical thinking is a metacognitive process through reflective judgment that aims to produce logical conclusions to reach a solution to a problem. Instruction in critical thinking is very important because it allows individuals to gain a more complex understanding of the information they face and promotes good decision making and problem solving in real-world applications (Larsson, 2017). Meanwhile, according to Ennis (2011) in Fasko et al. (2020), critical

### How to Cite:

Hosniyah, Yulianti, E., Sudrajat, A. K., & Hairiyah. (2023). The Development of PBL-Based Respiratory App Learning Media on Human Respiratory System Material to Improve Critical Thinking Skills of Grade 11th Students. *Jurnal Penelitian Pendidikan IPA*, 9(8), 6166-6173. <https://doi.org/10.29303/jppipa.v9i8.3587>

thinking skills are reflective thinking skills that focus on decision-making patterns about what to believe and what to do and can be accounted for. Developing critical thinking skills in students is very important to facilitate them in solving problems that often occur in everyday life so that if one day they find a new problem, they are expected to be able to solve the problem wisely (Anggraeni et al., 2023).

The results of the 2018 PISA study published by the Organization for Economic Co-operation and Development (OECD) show that Indonesia ranks 74 out of 79 countries. The score of students' reading ability in Indonesia is 371 in position 74 the score of Mathematics ability gets 379 in position 73, and the score of science ability 396 in position 71. Based on these results, the portrait of cognitive skills such as critical thinking skills in Indonesia is low. Learning is said to be good or successful, one of which can be seen from the learning outcomes. Good learning outcomes can be seen when the expected learning objectives can be achieved, but in reality not all learning outcomes are as expected.

Based on the analysis of cognitive abilities on Biology daily test questions on respiratory system material at SMAN 6 Yogyakarta, 38.8% of 36 students have cognitive learning outcomes that do not meet the standards. Low learning outcomes can be influenced by various factors, such as the use of learning models and approaches that are not varied and learning media that are not innovative and teachers do not facilitate students in their thinking process. Based on observations, biology learning at SMAN 6 Yogyakarta still applies teacher center learning, which is learning in which every activity is dominated by the teacher while students are only passive objects who receive what is delivered by the teacher. This kind of learning tends to make students feel bored so that it reduces interest and learning outcomes.

The use of learning media in the learning process has not been applied properly, monotonous and not innovative, this is reinforced by the results of the questionnaire analysis of students' problems as much as 94, 5% of 36 students experience boredom in the biology learning process. The feeling of boredom is because the teacher always uses the same or monotonous learning. Based on an interview with one of the biology teachers in class XI, the biology learning process uses learning media in the form of power points containing material and has never used other learning media. According to him, it happened because making innovative and technology-based media takes a long time in the process of making it, and requires special training, and he felt less competent in operating computer devices. Although teachers have used learning media such as power point as a tool to facilitate students' understanding, the content of the media mostly contains (text) or writing and minimal with pictures and even animations, still using

the lecture method which makes the learning process more teacher-centered learning.

The learning process is often faced with things that are unusual and outside the daily experience of students, so that teachers have difficulty teaching and students have difficulty in the process of understanding. Many things in Biology subjects that cannot be visualized, so it requires certain media. The human respiratory system is one of the biological materials studied in class XI which emphasizes the broad and complex scope of the material. Biological material with objects that cannot be seen directly by the sense of sight such as human respiratory system material should be presented with a real approach and there are visualizations and relevant to the daily lives of students. Interesting and clear visuals can develop the imagination of students, so that students can recognize the exact arrangement of the organs of the human respiratory system (Khosiyono et al., 2022).

Technological developments in the education sector do not make it easier for teachers to utilize available facilities and infrastructure or cellular phone facilities owned by students, such as the use of android-based learning media to improve the quality of biology learning in the classroom. The use of learning media such as power point which contains a lot of writing and minimal images makes students only able to understand the subjects taught by just reading and listening to the teacher's explanation, while the images displayed in the power point are considered by students to be less interesting so that students feel bored when learning takes place and students do not immediately understand the lessons taught by the teacher. In this case, the teacher must create an interesting learning process, so as to increase students' interest in learning because basically the learning process involves psychological factors from students. Interesting learning can present a pleasant and anxiety-free atmosphere so as to increase the interest and ability and learning outcomes of students.

Efforts that can be made by teachers to optimize the use of technology as an educational tool in presenting fun learning and potentially improving critical thinking skills by applying technology to the learning process. One solution to answer these problems is to develop good learning media by utilizing the latest technology and integrating a problem-based learning model that can improve critical thinking skills. the PBL learning model is an instructional strategy that allows students to develop critical thinking skills that they find in real life (Isnany et al., 2018).

Problem-based learning is a learning model that focuses on identifying a problem and developing a solution plan so that this learning model is designed to increase the potential of thinking to solve the problem (Harahap et al., 2021). PBL learning is learning designed

around comprehensive, real and complex problems that provide opportunities for learners to acquire knowledge, understanding and skills that have been determined by the curriculum (Valdez & Bungihan, 2019). Media has an important role in the learning process in the classroom. Learning media is useful as a communication tool or tool to clarify the material conveyed by the teacher so that the learning process is not only verbalize, to facilitate teachers in carrying out their duties, it is very important for teachers to use learning aids in the form of learning media (Muktiani et al., 2022).

Edgar Dale (1969) reinforced the importance of using media in the learning process at school by expressing an opinion known as Edgar Dale's cone of experience theory (Muhajarah & Rachmawati, 2019). The theory states that the success of one's learning depends on how much learning experience is obtained, both from the teacher and from one's own activities. Dale stated that the best way to learn is to learn from direct experience (Direct performance) and not just see how people do or even just tell stories. This theory proves that learning media plays a very important role in increasing the percentage of information that is remembered compared to learning with the lecture method.

According to Manurung (2020), good learning media is one that has interactive elements, interactive can be referred to as a relationship of interaction or mutual action between teachers and students with learning media and can also be interactive learning media, namely a combination of various media in file formats in the form of writing, images, graphics, sound (sound), animation, video, interaction, and others, which have been packaged into digital (computerized) files and used to convey messages to students. Learning media is needed by teachers to help convey material in a learning process. According to Mustaqim et al. (2017), a good learning process must be fun, challenging, motivating and provide more space for students to be able to develop students' skills and abilities. The learning media developed in this research is the result of analyzing the needs of teachers and students. Teachers want the use of cell phones during learning to be more useful in improving students' high order thinking skills.

The learning media developed in this research is based on the needs of teachers and the characteristics of students. The learning style characteristics of each learner are different but it is possible that there are learners who have the same learning style. Based on observation, it is known that grade XI students at SMAN 6 Yogyakarta have three types of learning styles, namely: visual, auditory, and kinesthetic. Visual learning style is a way of learning by seeing things, either through pictures, diagrams and video objects. Auditory learning

style is a way of learning through listening to something for example listening to audio tapes, lectures, discussions, debates, and verbal instructions. The kinesthetic learning style is a way of learning through physical activity and direct involvement.

The development of PBL-based Respiratory App learning media on human respiration system material is a solution to answer these problems. The development of Respiratory App learning media is a technological solution that allows for the advancement of active and student-centered teaching. The learning media developed has various advantages and advantages, namely easy to operate, combines all types of media so that it can facilitate the learning styles of different students, and students can choose the desired material, there are features of 3D objects, educational games, presented object problems, and use systematic control in learning. The existence of these features is expected to provide real and interesting visualization (because many things in biology material cannot be visualized directly so they require certain media), concretize complex material, make learning active and fun so as to attract interest in learning and improve critical thinking skills.

The use of application-based learning media allows the potential for distraction, so that students easily switch to activities that have no connection with learning such as opening social media. By integrating the PBL model into the learning media, learners can be actively involved in the learning process and be more proactive in seeking information and collaborating with their friends so as to reduce the potential for distraction. The use of PBL-based Respiratory App learning media in education can be an alternative learning media in schools that can improve 21st century skills, where 21st century learning requires students to be skilled in using media, information and technology, thinking and innovation skills and skills that can be used in life and career, one of these skills is critical thinking skills. Some studies show that the use of learning media by applying technology in its manufacture can improve 21st century skills known as 4C skills. Research by (Hendi et al., 2020), metacognitive-based interactive learning media developed is effective for improving students' critical thinking skills. Research by Isnaneny et al. (2018), shows that PBL-based interactive multimedia can improve students' critical thinking skills.

## Method

This kind of research is a Research and Development (R&D). This research and development method is used to produce certain new products through the development process, and test the effectiveness of these products. The development

procedure uses the ADDIE model developed by Dick and Carry (1996), this stage consists of Analyze (analysis), Design (design), Develop (development), Implement (implementation) and Evaluation (evaluation) (Yu et al., 2021; Suryani et al., 2022).

The analysis stage was conducted to find initial information related to the object and subject of research. At this stage the researcher conducted instructional analysis, competencies, curriculum and analysis of the characteristics of students at SMAN 6 Yogyakarta. After the analysis, the design of the learning media is produced and the determination of the features that will be in the learning media such as educational games, materials, practice questions, instructions for use, learning videos and developer profiles. At this stage, the design of evaluation tools and lesson plans is also carried out. The stages in this development process consist of pre-development, development, validation, revision I, limited scale trial and revision II. In the pre-development stage, a search was carried out related to references such as books, relevant research articles and issues or problems related to respiratory system material in organizing material content on learning media.

Development of Respiratory App learning media products based on the framework that has been made at the design stage. Media developed using canva and Smart Apps Creator applications. At this stage, Draft I of the problem-based Respiratory App learning media on human respiratory system material will be produced. Draft I of the Respiratory App learning media that has been developed is validated to get an assessment and suggestions from media experts and material experts regarding the feasibility of learning media.

The results of the validation of draft I were then revised to obtain draft II so that it could be applied to a limited trial. The limited trial was conducted to determine the practicality of the Respiratory App learning media. Based on the results of the trial, revision II will be made to the media which will then produce draft III learning media. Implementation stage is carried out to determine the effectiveness of learning media (Draft III) in improving critical thinking skills. Evaluation is the last stage in the learning media development process using the ADDIE model, Evaluation is conducted to evaluate the obstacles encountered, identify successes and recommend improvements for the next developer (Jayanti & Pertiwi, 2015).

The data collection techniques used in this research are non-test and test. The instruments used are observation sheets, interview sheets, questionnaires of students' needs, documentation and tests. Qualitative data obtained from the analysis stage such as interviews were analyzed descriptively qualitative, while the data obtained from the questionnaire of learners' needs were

converted to a scale table. The scores obtained are then converted into four-scale qualitative data. Analysis of the feasibility and practicability of PBL-based Respiratory App learning media obtained from the assessment sheets of media experts, material experts, biology subject teachers and students. The scores obtained are then converted into four-scale qualitative data as follows:

**Table 1.** Learning Media Feasibility Criteria (Ngurahrai et al., 2019)

Score	Feasibility Criteria	Description
$3.26 < \bar{x} \leq 4.00$	Feasible	No revision
$2.51 < \bar{x} \leq 3.26$	Feasible enough	Partial revision
$1.76 < \bar{x} \leq 2.51$	Less feasible	Partial revision and theory review
$1.00 < \bar{x} \leq 1.76$	Not feasible	Total revision

Measurement of the effectiveness of learning media to improve critical thinking skills using ANOVA test statistical analysis and N-gain scores. N-gain score criteria can be seen in table 2 below:

**Table 2.** N-gain score criteria (Hake, 1999)

Score	Criteria
$g \geq 0.7$	High
$0.3 \leq g < 0.7$	Medium
$g < 0.3$	Low

The interpretation of effectiveness based on the N-gain score can be seen in table 3 below:

**Table 3.** Interpretation of Learning Media Effectiveness (Nashiroh et al., 2020)

Percentages (%)	Category
$< 76$	Effective
56 - 75	Effective enough
40 - 55	Less effective
$< 40$	Ineffective

## Result and Discussion

The learning media designed and developed in this research is named PBL-based human respiratory system learning application (Respiratory App). The choice of the model is because the PBL learning model is considered appropriate for improving students' critical thinking skills (Yana et al., 2022). Respiratory App contains excellent features that allow learning activities to be active and fun such as educational games, 3D objects that can be rotated 360 degrees, problem objects and video features.

Video features contained in learning media can help students to see various sizes of objects, can describe objects or a process precisely and can even see an event

so that it can improve student skills. This is in accordance with the statement (Sustiyono, 2021), which states that video playback in learning activities can increase the emotional intelligence of the audience for those who watch it and can increase one's thinking power. The following is a screenshot of the PBL-based Respiratory App learning media developed:

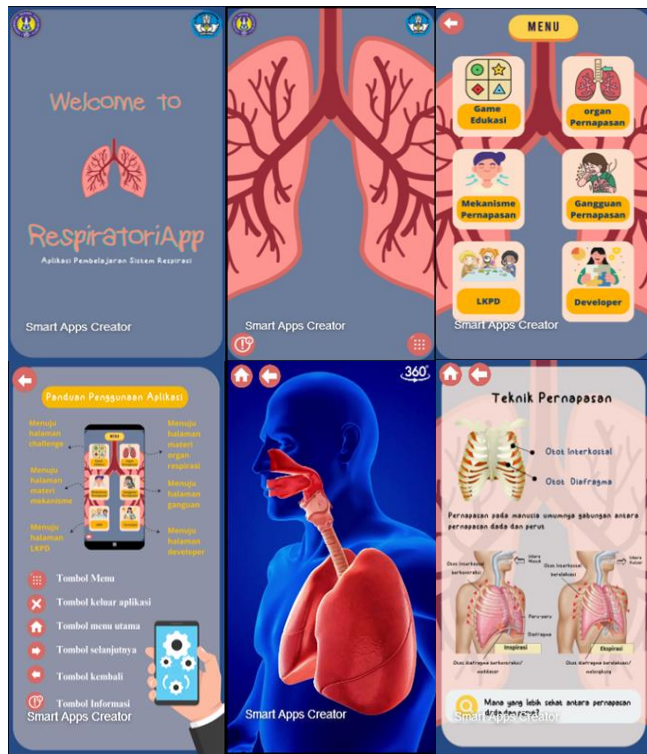


Figure 1. Display of learning media

Respiratory App learning media and learning tools that have been developed then enter the editing and assessment stage. The editing and assessment process is a stage to conduct a review of the media and learning tools that have been developed by obtaining assessments, suggestions, and input from experts consisting of media expert lecturers and material expert lecturers. The results of the Respiratory App learning media feasibility assessment by experts can be seen in table 4 below:

Table 4. Assessment of the Feasibility of Respiratory App Learning Media by Experts

Experts	Score	Criteria	Description
Material expert	3.0	Feasible enough	Partial revision
Media expert	3.8	Feasible	No Revision
Average	3.4	Feasible	Partial revision

Based on the assessment of PBL-based Respiratory App learning media can be categorized as feasible. PBL-based Respiratory App learning media has material that is clear and easy to understand, equipped with examples

of problems that are relevant to everyday life, and has clarity of image objects and animated videos that help in understanding the material. The use of language in learning media is considered communicative and easily understood by students. The learning media has an attractive appearance, color selection, type and size of the right font that adds to the readability and helps in understanding the material. Educational games contained in the media make learning more interesting, fun, and interactive. In the aspect of use, Respiratory App learning media is considered easy to operate.

Table 5. Assessment of the Practicability of Respiratory App Learning Media by Teacher and Student

Experts	Score	Criteria
Teacher	3.5	Practical
Student	3.3	Practical
Average	3.4	Practical

Based on the practicality test, the learning media developed obtained an average practicality score of 3.4 and based on these results, the PBL-based Respiratory App learning media is practical to be implemented in the field test.

Field tests were conducted in experimental and control classes with 36 students in each class. The learning carried out uses learning in accordance with the lesson plan that has been designed previously. The control class used power point media with PBL model while the experimental class used PBL-based Respiratory App learning media with PBL model.

Table 6. The Results of ANOVA Test

Variable	Sig	Description
KBK	0.000	There are differences

Based on the results of the ANOVA test analysis, the sig value is  $0.00 < 0.05$ , then the decision making  $H_0$  is rejected and  $H_a$  is accepted. Thus it can be stated that there is a significant difference in critical thinking skills between students who take part in learning using PBL-based Respiratory App learning media and students who take part in learning without using Respiratory App media. The difference can be seen from the N-gain score obtained between the control class and the experimental class as shown in table 7.

The results of the initial measurement of students' critical thinking skills show that the control class and the experimental class have abilities that are close to equal. After learning activities in the control class using the discovery learning model and with the help of power point learning media showed a moderate increase in critical thinking skills which can be seen from the N-gain score of 0.40. The initial ability of students in the control class has an average score of 51.39 and has an average

score at the final ability of 70.89. While in the experimental class that used Respiratory App learning media based on the PBL model showed an increase in critical thinking skills that was higher than the control class, the increase can be seen from the acquisition of the N-gain score in the experimental class of 0.77 with a high category. The initial ability of students in the experimental class had an average score of 51.86 and had an average score at the final ability of 89.25.

**Table 7.** The Result of N-gain Test

Group	N	Mean score		N-gain score	Des.
		Pre-test	Post-test		
Control	36	51.39	70.89	0.40	Medium
Experiment	36	51.86	89.25	0.77	High

To see whether the PBL-based Respiratory App learning media is effective or not in improving critical thinking skills, the N-gain score is interpreted into the media effectiveness percentage table, the control class has a percentage of 40%, indicating that the use of power point media is less effective in improving students' critical thinking skills, while in the experimental class the percentage of effectiveness of the PBL-based Respiratory App learning media is 77%, indicating that the use of PBL-based Respiratory App media is very effective in improving students' critical thinking skills.

PBL-based Respiratory App learning media emphasizes the characteristics of interactive multimedia combined with PBL models that can improve critical thinking skills. This is because multimedia is a combination of text, 2D and 3D images, sound, and video put together in one device. The visual, audio, and audio-visual aspects contained in the learning media provide direct experience of the concept of the respiratory system in an audio-visual manner, which can increase students' knowledge, stimulate reasoning power and critical thinking skills. Animated images, 3D objects and videos presented in Respiratory App media can help learners to change abstract concepts into more concrete concepts (Darmayanti et al., 2022).

Learning videos that are displayed can help students understand the material (Daryanes et al., 2023). Learning videos can also increase students' interest and learning outcomes, this is in accordance with the results of the study (Herlina et al., 2020). Interesting videos contained in PBL-based Respiratory App learning media can help students to see various sizes of objects, can describe objects or a process precisely and can even see an event so that it can improve students' thinking skills. This is in accordance with the statement of (Sustiyono, 2021), which states that video playback in learning activities can improve emotional intelligence such as mood for those who watch it and can increase one's thinking power. Emotional intelligence has a very

important role in critical thinking, because mood conditions can affect a person in making arguments, considering, and making logical decisions (Moon, 2008).

PBL-based Respiratory App learning media contains excellent features that allow learning activities to be active and fun such as learning video features, educational games and material packaged with relevant problems. The game feature or educational game on PBL-based Respiratory App learning media is designed and packaged with human respiratory system material so that it strengthens the material that has been given, learning by using educational games can be a basic capital for students to understand the material or strengthen the material that has been received.

Learning media that provide educational game features make the learning process fun and avoid boredom, positive learning experience, and a positive effect on student learning achievement besides that educational game can improve students' critical thinking skills (Fitriyana et al., 2020). This is in accordance with the statement of (Rozi & Kristari, 2020), which states that educational games can stimulate the thinking power of someone who plays them and can increase concentration in solving certain problems.

The PBL learning model with its characteristics emphasizes authentic problems and problem solving, which is believed to build thinking potential and curiosity to solve the problems found. Students' critical thinking skills can increase through the stage of guiding individual and group investigations contained in the PBL learning syntax. At that stage, students play a very important role in thinking about solving a problem with the most appropriate solution. In accordance with the statement of (Pusparini et al., 2018), which states that the problems presented are not just presented, but students are required to identify to find a solution to the problem. The solution to the problem is sought together with group members. The feeling of being involved with the group makes students able to face challenges and be motivated in learning, especially in terms of providing conclusions or solutions.

The application of Problem-Based learning model can improve critical thinking skills because students become more active and able to use their thinking skills, students are not only passive in accepting the explanation delivered by the teacher. It has been agreed that in Problem Based Learning, students are required to actively develop their thinking skills to formulate problems and find solutions in solving problems, so as to develop their critical thinking skills (Suastra et al., 2019).

In addition, PBL promotes the development of learners' metacognitive abilities and teamwork. In such learning situations, reflecting reality, encouraging problem-based learning, interaction, cooperation,

negotiation, and inclusiveness indirectly improves learners' social skills (Chao et al., 2017).

Learning that trains students' critical thinking skills as a means to prepare students to join the world of work who are able to think analytically, solve problems and critically so that they can become a professional, productive workforce and produce knowledge, be able to exchange information and encourage progress that helps the development of community welfare (Sasson et al., 2018).

## Conclusion

The conclusion of this research is that Respiratory App learning media based on PBL is feasible to use as media in supporting the learning process on the material of the human respiratory system and Respiratory App learning media based on PBL on the material of the human respiratory system is effective in improving critical thinking skills.

## Acknowledgments

Thank you to the Postgraduate program, Department of Mathematics and Natural Sciences, Biology Education Study Program, Yogyakarta State University for facilitating this research to completion and the researcher is also grateful to the biology subject teacher at SMAN 6 Yogyakarta for providing support and permission to carry out research.

## Author Contributions

Hosniyah: The main author who prepares the initial draft, results, discussion, methodology, conclusion; Evy Yulianti, Ahmad Kamal Sudrajat: analysis, checking, reviewing, and editing; Hairiyah: Editing and checking.

## Funding

This research was conducted with self-funding.

## Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

## References

- Anggraeni, D. M., Prahani, B. K., Suprpto, N., Shofiyah, N., & Jatmiko, B. (2023). Systematic review of problem based learning research in fostering critical thinking skills. *Thinking Skills and Creativity*, 49, 101334. <https://doi.org/10.1016/j.tsc.2023.101334>
- Chao, J. Y., Tzeng, P. W., & Po, H. Y. (2017). The study of problem solving process of e-book PBL course of atayal senior high school students in Taiwan. *Eurasia Journal of Mathematics, Science and Technology Education*, 13(3), 1001-1012. <https://doi.org/10.12973/eurasia.2017.00654a>
- Darmayanti, Sri. N. W., Artini, Juni N. P.,...& Januariawan, W., (2022). *Strategi Pembelajaran IPA di Sekolah Dasar (SD)*. Banyumas: CV Pena Persada.
- Daryanes, F., Darmadi, D., Fikri, K., Sayuti, I., Rusandi, M. A., & Situmorang, D. D. B. (2023). The development of articulate storyline interactive learning media based on case methods to train student's problem-solving ability. *Heliyon*, 9(4), e15082. <https://doi.org/10.1016/j.heliyon.2023.e15082>
- Fasko, D., & Fair, F. (2020). *Critical Thinking and Reasoning: Theory, Development, Instruction, and Assessment*. Boston: Brill.
- Fitriyana, N., Wiyarsi, A., Ikhsan, J., & Sugiyarto, K. H. (2020). Android-based-game and blended learning in chemistry: Effect on students' self-efficacy and achievement. *Cakrawala Pendidikan*, 39(3), 507-521. <https://doi.org/10.21831/cp.v39i3.28335>
- Harahap, A., Irwan, Musdi, E., & A, A. (2021). Pengembangan Media Pembelajaran Interaktif Berbasis Problem Based Learning (PBL) Berbantuan Android Untuk Meningkatkan Kemampuan Pemecahan Masalah Matematis Peserta Didik Kelas VII SMP Negeri 1 Sosopan. *JEMS: Jurnal Edukasi Matematika Dan Sains*, 9(2), 371-383. <https://doi.org/10.25273/jems.v9i2.10634>
- Hendi, A., Caswita, C., & Haenilah, E. Y. (2020). Pengembangan Media Pembelajaran Interaktif Berbasis Strategi Metakognitif untuk Meningkatkan Kemampuan Berpikir Kritis siswa. *Jurnal Cendekia: Jurnal Pendidikan Matematika*, 4(2), 823-834. <https://doi.org/10.31004/cendekia.v4i2.310>
- Herlina, M., Syahfitri, J., & Oktariani, Y. (2020). Pengaruh Model Pembelajaran Pbl Menggunakan Media Audio Visual Terhadap Minat Dan Hasil Belajar Biologi. *Jurnal BIOEDUIN: Program Studi Pendidikan Biologi*, 10(1), 46-53. <https://doi.org/10.15575/bioeduin.v10i1.8164>
- Isnaniy, F. Y., Sajidan, S., & Masykuri, M. (2018). Pengembangan Multimedia Interaktif Berbasis Problem Based Learning (PBL) Untuk Meningkatkan Kemampuan Berpikir Kritis Mahasiswa Program Studi Pendidikan Biologi Ums Pada Materi Sistem Gerak Manusia. *INKUIRI: Jurnal Pendidikan IPA*, 7(1), 111. <https://doi.org/10.20961/inkuiri.v7i1.19798>
- Jayanti, M. A., & Pertiwi, R. K. (2015). Pengembangan e-modul berbasis PBL untuk meningkatkan kemampuan analisis dan rasa ingin tahu siswa. *JINoP (Jurnal Inovasi Pembelajaran)*, 1(1), 112-127. <https://doi.org/10.22219/jinop.v1i1.2441>
- Khosiyono, B. H. C., Fajarudin, M., Jayanti, E. D., Sari, R. V., Srikonita, R., Isnaini, L., Kholisoh, S., Sunardiyah, M. A., & Hikmah, N. (2022). *Teori dan*

- Pengembangan Pembelajaran Berbasis Teknologi Digital di Sekolah Dasar*. Yogyakarta: Deepublish
- Larsson, K. (2017). Understanding and teaching critical thinking – A new approach. *International Journal of Educational Research*, 84, 32–42. <https://doi.org/https://doi.org/10.1016/j.ijer.2017.05.004>
- Lase, D. (2020). Pendidikan Di Era Revolusi Industri 4.0. *Jurnal Teknologi Industri Dan Rekayasa (JTIR)*, 1(1), 43–48. <https://doi.org/10.53091/jtir.v1i1.17>
- Manurung, P. (2020). Multimedia Interaktif Sebagai Media Pembelajaran Pada Masa Pandemi Covid 19. *Al-Fikru: Jurnal Ilmiah*, 14(1), 1–12. <https://doi.org/10.51672/alfikru.v14i1.33>
- Muktiani, N. R., Soegiyanto, Siswantoyo, Rahayu, S., & Hermawan, H. A. (2022). Augmented reality mobile app-based multimedia learning of Pencak Silat to enhance the junior high school students' learning outcomes. *Cakrawala Pendidikan*, 41(2), 553–568. <https://doi.org/10.21831/cp.v41i2.49217>
- Moon, J. (2008). Critical thinking: An exploration of theory and practice. In *Critical Thinking: An Exploration of Theory and Practice*. Taylor & Francis Group. <https://doi.org/10.4324/9780203944882>
- Muhajarah, K., & Rachmawati, F. (2019). Game Edukasi berbasis Android: Urgensi Penggunaan, Pengembangan dan Penguji Kelayakan. *Justek: Jurnal Sains Dan Teknologi*, 2(2), 29. <https://doi.org/10.31764/justek.v2i2.3733>
- Mustaqim, I., & Kurniawan, N. (2017). Pengembangan bahan ajar perakitan komputer bermuatan augmented reality untuk menumbuhkan keaktifan belajar siswa. *Tekno*, 29(2), 97. <https://doi.org/10.17977/um034v29i2p97-115>
- Nashiroh, P. K., Ekarini, F., & Ristanto, R. D. (2020). Efektifitas Penerapan Model Pembelajaran Kooperatif Tipe Jigsaw Berbantuan Mind Map Terhadap Kemampuan Pedagogik Mahasiswa Mata Kuliah Pengembangan. *Jurnal Pendidikan dan Teknologi*, 17(1), 43–52. <https://doi.org/10.23887/jptk-undiksha.v17i1.22906>
- Ngurahrai, A. H., Farmayanti, S. D., & Nurhidayati. (2019). Pengembangan Media Pembelajaran Fisika Berbasis Mobile Learning Untuk Meningkatkan Kemampuan Berpikir Kritis Peserta Didik. *RADIASI: Jurnal Berkala Pendidikan Fisika*, 12(2), 76–83. <https://doi.org/10.37729/radiasi.v12i2.55>
- Pusparini, S. T., Feronika, T., & Bahriah, E. S. (2018). Pengaruh Model Pembelajaran Problem Based Learning (PBL) Terhadap Kemampuan Berpikir Kritis Siswa pada Materi Sistem Koloid. *JRPK: Jurnal Riset Pendidikan Kimia*, 8(1), 35–42. <https://doi.org/10.21009/jrpk.081.04>
- Rozi, F., & Kristari, A. (2020). Pengembangan Media Pembelajaran Game Edukasi Berbasis Android Pada Mata Pelajaran Fisika Untuk Siswa Kelas Xi Di Sman 1 Tulungagung. *JUPI (Jurnal Ilmiah Penelitian Dan Pembelajaran Informatika)*, 5(1), 35. <https://doi.org/10.29100/jupi.v5i1.1561>
- Sasson, I., Yehuda, I., & Malkinson, N. (2018). Fostering the skills of critical thinking and question-posing in a project-based learning environment. *Thinking Skills and Creativity*, 29, 203–212. <https://doi.org/10.1016/j.tsc.2018.08.001>
- Suastra, I. W., Ristiati, N. P., Adnyana, P. P. B., & Kanca, N. (2019). The effectiveness of Problem Based Learning - Physics module with authentic assessment for enhancing senior high school students' physics problem solving ability and critical thinking ability. *Journal of Physics: Conference Series*, 1171(1). <https://doi.org/10.1088/1742-6596/1171/1/012027>
- Suryani, D., Yasir, M., Science, R. S.-J. of S. and, & 2022, U. (2022). 271. Development of Ethnoscience-Oriented Multimedia Learning Process of Salt Making on Conductivity Materials on the Response of Junior High School Students. *Journal of Science and Science Education*, 3(2), 76. Retrieved from <https://www.jppipa.unram.ac.id/index.php/jossed/article/view/1841>
- Sustiyono, A. (2021). Perbedaan Efektifitas Metode Ceramah dan Media Video dalam Meningkatkan Pengetahuan Pembelajaran Praktikum Keperawatan. *Faletahan Health Journal*, 8(02), 71–76. <https://doi.org/10.33746/fhj.v8i02.241>
- Valdez, J. E., & Bungihan, M. E. (2019). Problem-based learning approach enhances the problem solving skills in chemistry of high school students. *Journal of Technology and Science Education*, 9(3), 282–294. <https://doi.org/10.3926/JOTSE.631>
- Yana, S., Yusrizal, Y., Halim, A., Syukri, M., & Elisa, E. (2022). Application of Problem Based Learning (PBL) Model to Improve Problem Solving Skill from Critical Thinking Skill Students on Dynamic Fluid Materials. *Jurnal Penelitian Pendidikan IPA*, 8(2), 521–527. <https://doi.org/10.29303/jppipa.v8i2.1329>
- Yu, S.-J., Hsueh, Y.-L., Sun, J. C.-Y., & Liu, H.-Z. (2021). Developing an intelligent virtual reality interactive system based on the ADDIE model for learning pour-over coffee brewing. *Computers and Education: Artificial Intelligence*, 2, 100030. <https://doi.org/10.1016/j.caeai.2021.100030>