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ANALYSIS OF THE FEASIBILITY OF SCIENCE LEARNING MULTIMEDIA BASED ON SCIENTIFIC INQUIRY

Analisis Kelayakan Multimedia Pembelajaran IPA Berbasis Scientific Inquiry

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INFORMASI ARTIKEL

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***ABSTRACT**:*

Scientific inquiry-based science learning multimedia plays a very important role in fostering students' critical thinking skills. This study aims to analyze the feasibility of the media that has been made based on input from experts. This study involved 15 experts consisting of material experts, linguists, media experts, and learning design experts as well as educational practitioners. Based on calculations using Aiken's V, it shows that the entire index V > 0.79 (V table Aiken). This proves that all items contained in the questionnaire represent the construct being measured and are said to have adequate content validity. In addition, input from experts was also analyzed qualitatively. Thus, interactive multimedia products are said to be valid for use as science learning media. This media can be a recommendation for teachers to teach science, especially in abstract material and can train students' critical thinking skills.

ABSTRAK

Multimedia pembelajaran IPA berbasis *scientific inquiry* sangat berperan dalam menumbuhkan keterampilan berpikir kritis siswa. Adapun penelitian ini bertujuan

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untuk menganalisis kelayakan media yang telah dibuat berdasarkan masukan dari para ahli. Penelitian ini melibatkan 15 ahli yang terdiri dari ahli materi, ahli bahasa, ahli media, dan ahli desain pembelajaran serta praktisi pendidikan. Berdasarkan perhitungan menggunakan Aiken's V menunjukkan bahwa seluruh indeks V > 0.79 (V tabel Aiken). Hal ini membuktikan bahwa seluruh item yang terdapat pada kuesioner mewakili konstrak yang diukur dan dikatakan memiliki validitas isi yang memadai. Di samping itu masukan dari para ahli juga dianalisa secara kualitatif. Dengan demikian, produk multimedia interaktif dikatakan valid digunakan sebagai media pembelajaran IPA. Media ini dapat menjadi rekomendasi bagi para guru untuk membelajarkan IPA khususnya pada materi yang abstrak dan dapat melatih keterampilan berpikir kritis siswa.

INTRODUCTION

Simply put, critical thinking is the ability to analyze and evaluate data or information (Ennis, 2018). Based on the opinion above, it can be said that students who have critical thinking skills, if given information or a problem, then the student will automatically analyze the information first by looking for other relevant information and then evaluating the results of all the information he gets.

The process of critical thinking is always based on rational and careful thinking. Slavin argues that critical thinking includes identifying misleading advertisements, weighing conflicting evidence, and identifying assumptions or fallacies in arguments (Slavin, 2009). In Slavin's opinion, it can be explained that critical thinking is a complex process that includes several efforts that work in the mind. This effort was made because there was something that was considered untrue and something that was considered untrue was then analyzed through the evidence that was in the mind, giving rise to a new belief.

Based on some of the opinions above, it can be described that critical thinking is a complex process that occurs in the human brain in the form of interpretation and evaluation of information obtained logically. The information is then sorted so that it can be used as material for logical

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reasoning. The result of critical thinking is a belief in something that can guide a person in acting (Nippold, 2015; Urbani et al., 2017).

These critical thinking skills need to be instilled from an early age because they are not born by themselves. These skills need to be trained on an ongoing basis. There fore these skills can be integrated into learning in elementary schools, one of which is science content. In learning in elementary schools, science has several characteristics, including 1) the ability to know what is observed, 2) the ability to predict what has not been observed, and 3) the development of a scientific attitude. around systematic ways that will be applied in the environment and technology. These three abilities are integrated with critical thinking skills where students can predict, analyze, evaluate a case, and find alternative solutions to the problem.

Based on the preliminary study conducted by the researcher, showed several indicators of the limited scores of students in science critical thinking skills, including (1) there was science learning material that was difficult for students to understand as a whole, (2) the limitations of the media for delivering abstract science material, for example in system-related material digestion, respiration, and blood circulation because they cannot be contextualized (3) teachers need effective, flexible, and easy-to-use media for teachers and students to actively explore science concepts. If the limitations of this media are not immediately overcome, science learning will not be meaningful in students' lives.

One of the media that can facilitate students' thinking skills is interactive multimedia. Interactive multimedia is a multimedia display that combines text, graphics, audio, video, and animation and its appearance fulfills the function of informing messages and having interactivity to its users. Multimedia can affect a person's high-level cognitive skills such as problem-solving, hypothesis testing, decision-making, evaluation, and self-reflection. Of course, this is following the existence of multimedia which combines text, graphics, audio, video, and animation so that it can inform messages clearly and interestingly. Through interactive multimedia, the learning presented becomes more concrete and fun. Especially in science

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content which has abstract characteristics, it can be presented concretely with this media. This is because interactive multimedia can present concrete situations in a material that may be difficult to present realistically in front of students. In addition, learning through interactive multimedia is well not limited by space and time. Students can learn to understand the material repeatedly based on their wishes (Azizatunnisa et al., 2022; Bellaera et al., 2021; Wu et al., 2018). Of course, this can facilitate all the cognitive levels that students themselves have.

Interactive multimedia has several advantages that make it superior to other media. Several studies have proven that interactive multimedia can improve students' conceptual understanding and learning motivation (Anisimova, 2020; Gunawan, 2020; Jong et al., 2021; Pardjono, 2020). Multimedia has been proven to improve high-order thinking skills. In addition, interactive multimedia can also improve vocabulary and the ability to associate images, audio, and video. The integration of text, images, sound, and animation can attract students' concentration and stimulate them to understand concepts and subject matter, in addition to the integration of text, graphics, animation, and images which make learning more concrete and fun (Husein, 2021; Pan et al., 2021; Samaniego-Mena, 2020).

In this case, researchers will develop scientific inquiry-based interactive multimedia to improve students' critical thinking skills in science learning. Scientific Inquiry was chosen because it aims to train students' skills in researching, explaining phenomena, and solving problems scientifically (Fazio et al., 2020; Hasanah, Uswatun, Astra, 2023; Hasanah, 2021). Scientific inquiry-based learning is designed to involve students in research problems that are truly original by exposing students to the field of investigation, helping students identify conceptual or methodological problems in that field, and inviting students to be able to design ways to solve these problems (Chen, 2022; Lin et al., 2022; Stylinski et al., 2020). A systematic and scientific process carried out can stimulate students' critical thinking skills.

METHOD

This research includes development research. Development

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research is research-oriented to develop and validate products used in education. The model used is the Diana Lee and Owens model which consists of (1)multimedia need assessment and analysis, (2) multimedia instructional design, 3) multimedia development and implementation, and (4) multimedia evaluation (William W. Lee, 2004). This study focuses on the third stage, namely multimedia development, and implementation. At this stage, the researcher analyzes the feasibility of the media products that have been made. This article emphasizes the development of scientific inquiry-based Interactive Multimedia in science learning through the validation of material experts, media experts, linguists, and learning experts.

This interactive multimedia feasibility test involves fifteen experts who have different scientific characteristics according to their expertise. Validation was carried out by material experts, linguists, media experts, and learning design experts. In addition, the product was also validated by practitioners, namely elementary school teachers by distributing response questionnaires to interactive science multimedia.

RESULT AND DISCUSSION

Material Expert Validation Results

Material validation focuses on (1) material accuracy, (2) material depth, (3) material balance, (4) presentation accuracy at the level of material detail, (5) material meaningfulness, (6) material attractiveness, (7) material suitability with student characteristics, and (8) clarity of material with learning objectives. The results of the validation carried out by experts are as follows:

Table 1: Material Expert Suggestions and Improvements

No	Validators	Suggestions and Improvements	Follow-up
1	Material Expert 2	It is better if the learning objectives are written on the slide before "Let's Ask" and not just sounded.	Suggestions from the validator were immediately followed up by researchers. Learning objectives have been written on the slide before "Let's Ask".
2	Material Expert 2	There is animated video material that is not following the learning objectives.	Animated videos are reproduced and adjust the learning objectives
3	Material Expert 1	The illustrations and information in comprehension quiz number 2	Illustrations adapted to the information contained in the problem.

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No	Validators	Suggestions and Improvements	Follow-up
		are not appropriate.	
4	Material Expert 2	Develop questions on "Let's analyze" that train children to think critically.	On the "Let's Analyze" slide, questions are added that stimulate students' reasoning.
5	Material Expert 3	Add back the “Let's analyze” activity to stimulate critical thinking skills.	Researchers have added Let's analyze activities on each material topic.
6	Practitioner	The material for human locomotor organs is added with information on how to take good care of bones	Feedback has been followed up. Information on how to maintain bone health has been added to the video material "human organs of Movement".

Based on the suggestions and input from material experts and practitioners, it is stated that the material in this multimedia is following the objectives of learning science in class V semester I where science material consists of the movement organs of animals and humans, the respiratory system of animals and humans, the digestive system of animals and humans, and circulatory system of animals and humans. Experts and practitioners also agree that these materials are difficult if only taught verbally, so it is appropriate to make media that facilitate student understanding. Material expert 2 stated that the material endeavored to be adapted to the needs analysis and curriculum development. In line with this, practitioners also state that material is also contained in the 2013 curriculum and the independent curriculum. In terms of material determination,

In addition, the three material experts and practitioners agree that this material is accurate, meaningful, interesting, and follows the developmental characteristics of students. Animation displays, video explanations, and learning activities in them help students understand lessons and stimulate students thinking skills. In addition to suggestions and input from experts, the results of the validation were also analyzed quantitatively using Aiken's V to calculate the content-validity coefficient which is based on the results of an assessment by a panel of experts of n people on an item in terms of the extent to which the item represents the construct being measured. The results of material validation will be explained in the following table:

Table 2: Material Validation Results

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Items	Total s (score-1)	Index Aikens'V	Information
1	23	0.96	Valid
2	22	0.92	Valid
3	22	0.92	Valid
4	21	0.88	Valid
5	21	0.88	Valid
6	20	0.83	Valid
7	21	0.88	Valid
8	22	0.92	Valid
9	23	0.96	Valid
10	20	0.83	Valid
11	23	0.96	Valid
12	20	0.83	Valid
13	23	0.96	Valid
14	22	0.92	Valid
15	22	0.92	Valid

Based on calculations using Aiken's V, it shows that the entire index V > 0.79 (V table Aiken). This proves that all items contained in the questionnaire represent the construct being measured and are said to have adequate content validity. Thus, interactive multimedia products are said to be valid for use as science learning media.

Linguist Validation Results

In this case, the validator focuses on the language contained in the multimedia so that it complies with the Indonesian General Spelling Guidelines (PUEBI). The aspects of language assessment include (1) the suitability of language with the level of student development, (2) coherence and integration of thinking, (3) grammar, and (4) appearance/typography of media content. The description of the improvement can be seen in the following table:

Table 3: Language Expert Suggestions and Improvements

No	Validators	Suggestions and Improvements	Follow-up
1	Linguists 1, 2, 3	There are several typing errors (typos) and punctuation in the writing of words and sentences.	Researchers have identified a typo and fixed it immediately.
2	Linguist 2	Writing for the word "di" which indicates a separate place while the word "di" is an affix, the writing is mixed up.	The researcher immediately corrected the writing error "in" according to PUEBI rules.
3	Linguist 3	The use of interrogative sentences in comprehension quizzes is not effective	The researcher immediately fixes the interrogative sentences into operational effective sentences.
4	Linguists 1, 3	Writing the title of the subject matter should be uniform, put capital letters in front, and write and not be abbreviated &.	The researcher immediately corrected the validator's suggestions
5	Linguist 2	In the study guide, the sentences presented were difficult for fifth-grade students to understand.	Feedback has been followed up with improvements. The sentences in the study guide are made simpler so that they are easy to understand.
6	Practitioner	Writing foreign words should be translated,	Feedback has been followed up with

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No	Validators	Suggestions and Improvements	Follow-up
		for example, by the system.	improvements. The word system is changed to the system.
7	Practitioner	Information on the problem is less effective.	Feedback has been followed up with improvements. The question sentence in the question is changed to an effective sentence.
8	Practitioner	The text sent should be changed to try again so that it can be used as an exercise for students.	Feedback has been followed up with improvements.

Based on the suggestions and input of linguists and practitioners, it is stated that the language used in this multimedia has been largely adapted to the level of student development, coherence, and the integration of the flow of thought, grammar, and appearance/typography of media content. But there are still a few mistakes in typing (typos), capital letter errors, and using less effective sentences. This mistake has been followed up by researchers so that overall the language in multimedia is appropriate. Experts and practitioners agree that in terms of language, this multimedia is very interesting and has a good integrated flow of thought. The language used is coherent according to the flow of students' thinking, and the level of difficulty and coherence is good

In addition to suggestions and input from experts, the results of the validation were also analyzed quantitatively using Aiken's V to calculate the content-validity coefficient which is based on the results of an assessment by a panel of experts of n people on an item in terms of the extent to which the item represents the construct being measured. The results of language validation will be explained in the following table:

Table 4: Language Validation Results

Items	Total s (score-1)	Index Aikens'V	Information
1	21	0.88	Valid
2	21	0.88	Valid
3	20	0.83	Valid
4	21	0.88	Valid
5	21	0.88	Valid
6	22	0.92	Valid
7	24	1	Valid
8	21	0.88	Valid
9	22	0.92	Valid
10	22	0.92	Valid
11	21	0.88	Valid

Based on calculations using Aiken's V, it shows that the entire index V > 0.79 (V table Aiken). This proves that all items contained in the questionnaire represent the construct being measured and are said to have adequate content validity. Thus, interactive multimedia products are

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said to be valid for use as science learning media.

Learning Design Expert Validation Results

In validating the learning design, the expert focused on whether the interactive multimedia developed was following the characteristics of science learning in fifth-grade elementary school students. The aspects of learning design assessment include (1) Conformity of science learning objectives with multimedia material, (2) Conformity between evaluation indicators measured and learning objectives, (3) Suitability of media delivery strategy with audience (student) characteristics, (4) The accuracy of the media delivery strategy with scientific inquiry activities to enable ease and speed of understanding and mastery of material, concepts or skills, (5) The level of possibility that multimedia encourages students' ability to think critically and solve problems, (6) The level of contextuality with application/application in real life according to the characteristics of the audience (students), (7) Material can generate student motivation, and (8) Relative advantage, the accuracy of choosing media compared to other media. The description of the improvement can be seen in the following table:

Table 5: Learning Design Expert Advice and Improvements

No	Validators	Suggestions and Improvements	Follow-up
1	Learning Design Expert 1, 2, 3	In Come On, ask, it's best to ask students to write down questions according to what they see from the video (not directly providing the questions)	In the Let's Ask activity, students are allowed to write questions independently in the column provided.
2	Learning Design Expert 2, 3	• Add a final evaluation • Add evaluate button	• The final evaluate button added • The final evaluation slide added
3	Learning Design Expert 3	The concept and syntax of scientific inquiry learning need to be readjusted to the theory. It is written on the initial profile of the material so that the flow can be seen.	The researcher carried out a state of the art to operationalize the scientific inquiry learning syntax and wrote it on the initial profile of the material.
4	Practitioner	Animation is not following the learning objectives	Feedback has been followed up with improvements.

Based on suggestions and input from learning design experts and practitioners, it is stated that the learning activities contained in the multimedia are following the objectives of learning science, the scientific inquiry model, and the learning evaluation indicators that

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have been determined. In addition, they agree that the flow of learning in multimedia encourages students' ability to think critically and solve problems and has a level of contextuality with application/application in real life according to the characteristics of the audience (students). The media delivery strategy allows for ease and speed of understanding and mastery of material, concepts, or skills.

In addition to suggestions and input from experts, the results of the validation were also analyzed quantitatively using Aiken's V to calculate the content-validity coefficient which is based on the results of the assessment from a panel of experts of n people on an item in terms of the extent to which the item represents the construct being measured. The results of the learning design validation will be explained in the following table:

Table 6: Learning Design Validation Results

Items	Total s (score-1)	Index Aikens'V	Information
1	23	0.96	Valid
2	23	0.96	Valid
3	23	0.96	Valid
4	23	0.96	Valid
5	20	0.83	Valid
6	21	0.88	Valid
7	22	0.92	Valid
8	21	0.88	Valid
9	23	0.96	Valid
10	23	0.96	Valid
11	22	0.92	Valid
12	22	0.92	Valid
13	21	0.88	Valid
14	22	0.92	Valid
15	23	0.96	Valid
16	22	0.92	Valid
17	23	0.96	Valid
18	23	0.96	Valid
19	23	0.96	Valid
20	23	0.96	Valid

Based on calculations using Aiken's V, it shows that the entire index V > 0.79 (V table Aiken). This proves that all items contained in the questionnaire represent the construct being measured and are said to have adequate content validity. Thus, interactive multimedia products are said to be valid for use as science learning media.

Media Expert Validation Results

The media validation aims to maximize the quality of the developed interactive multimedia. The aspects that become media assessments include (1) Appropriateness and quality of the use of graphics and visuals with the objectives, material content, methods, and characteristics of the audience (students),

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(2) Appropriateness and quality of the use of audio and narration with the objectives, material content, methods and characteristics of the audience (students), (3) Appropriateness and quality of using video for its purpose, content, method, and characteristics of the audience (students), (4) Suitability and quality of using animation for the purpose, content, method, and characteristics of the audience (students), (5) Appropriateness and quality of using the language of communication for the purpose, content, methods, and characteristics of the audience (students), (6) the level of interactivity and ease of navigation, and (7) Overall media packaging attractiveness.

The description of the improvement can be seen in the following table:

Table 7: Media Expert Suggestions and Improvements

No	Validators	Suggestions and Improvements	Follow-up
1	Media Expert 2, 3	The background is too strong so it disturbs students' concentration	The background is reduced in volume and adjusted to the substance of the material
2	Media Expert 3	Icon pointers and reflections need to be adjusted.	The validator's suggestion was immediately followed up by the researcher. The study guide and reflection icons have been adapted to their meaning.
3	Media Expert 1	Navigation needs to be redesigned to make it easier for students (there are next and home buttons not working).	The next and home buttons have been revised.
4	Media Expert 1	Added video animation "human blood circulation"	Researchers developed an animated video of human blood circulation
5	Media Expert 2	The use of email for access can be directed to students so that students' digital literacy is getting better (on let's reflect)	In the "Let's Reflect" section, an active email column is added to train students' digital literacy.
6	Media Expert 3	Worksheets are also geared towards producing videos or products.	According to the validator's suggestion, in the Let's analyze activity, specifically for the worksheet, a product or video "upload" menu is added.
7	Practitioner	After installing the Multimedia application for the PC, the application does not appear on the desktop. So you always have to repeat the installation, but the installation for mobile is good.	The Multimedia application for PC doesn't need to be reinstalled because it works in a portable way, just open the folder and then open the file.
8	Practitioner	• The teacher's email column is	Feedback has been followed up

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No	Validators	Suggestions and Improvements	Follow-up
		deleted and the name column is accompanied by the student's name. • Need to set the sound volume.	with improvements.

Based on suggestions and input from media experts and practitioners, it shows that this interactive multimedia packaging is very interesting for fifth-grade students. In addition, the use of graphics, visuals, animation, and the use of communication materials is following the objectives, content, methods, and characteristics audience (students). The level of interactivity in this multimedia is quite good, not only for students to operate the navigation buttons, but also for students to move objects, classify objects, answer questions, and make a flow or chart of the respiratory, digestive, and circulatory systems as well as quite a lot of interaction between multimedia and users. As for navigation, there are still a small number of operational media that are not functioning.

In addition to suggestions and input from experts, the results of the validation were also analyzed quantitatively using Aiken's V to calculate the content-validity coefficient which is based on the results of an assessment by a panel of experts of n people on an item in terms of the extent to which the item represents the construct being measured. The media validation results will be explained in the following table:

Table 8: Media Validation Results

Items	Total s (score-1)	Index Aikens'V	Information
1	23	0.96	Valid
2	22	0.92	Valid
3	22	0.92	Valid
4	22	0.92	Valid
5	19	0.79	Valid
6	21	0.88	Valid
7	22	0.92	Valid
8	20	0.83	Valid
9	19	0.79	Valid
10	21	0.88	Valid
11	21	0.88	Valid
12	20	0.83	Valid
13	20	0.83	Valid
14	19	0.79	Valid
15	21	0.88	Valid
16	21	0.88	Valid
17	22	0.92	Valid
18	22	0.92	Valid
19	22	0.92	Valid
20	21	0.88	Valid
21	21	0.88	Valid
22	22	0.92	Valid
23	19	0.79	Valid
24	22	0.92	Valid
25	22	0.92	Valid
26	22	0.92	Valid
27	22	0.92	Valid

Based on calculations using Aiken's V, it shows that the entire index V > 0.79 (V table Aiken). This proves that all items contained in the

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questionnaire represent the construct being measured and are said to have adequate content validity. Thus, interactive multimedia products are said to be valid for use as science learning media.

Thus based on the feasibility test, interactive multimedia products developed by researchers are said to be suitable for use. Interactive multimedia developed by researchers have shown an interaction between multimedia and cognitive processes during learning. This interaction is known as the learning multimedia cognitive theory model developed by Mayer (Anisimova, 2020; Modlinger, 2020; Takaya, 2019). Meaningful learning requires students' participation in cognitive processes during learning, but students' capacity to use their cognitive processes has limitations. To overcome this, the teacher must create recognition through the use of multimedia, the use of learning multimedia has sensitivity to the load of students' cognitive processes during learning (Mayer & Moreno, 1998; Ruth Clack & Mayer, n.d.).

In this study, the developed science interactive multimedia has been adapted to the characteristics of elementary school-age children. In line with Bruner's theory, a person's cognitive development occurs through three stages, enactive, iconic, and symbolic (Takaya, 2019; Tampubolon, 2020). In elementary school-age children, children have gone through the iconic phase and entered the symbolic phase. At this stage, the child has begun to understand objects through pictures, recordings, or verbal visualization. In addition, children also begin to recognize symbols of language and logic. Therefore the existence of interactive multimedia can facilitate cognitive abilities in understanding the content of the lesson.

CONCLUSION

Based on expert validation of material, language, media, and learning design shows that scientific inquiry-based science multimedia is said to be suitable for use as a learning medium.

Based on calculations using Aiken's V, it shows that the entire index V > 0.79 (V table Aiken). This proves that all the items contained in the questionnaire represent the construct being measured and are said to have adequate content validity, language, media, and learning design validity. Thus, interactive multimedia products

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are said to be valid for use as science learning media.

This media can be used as an alternative solution to clarify the concept of science material to students, especially material that is abstract and really needs media, for example the circulatory system, digestive system, and respiratory system of animals and humans. The method of delivering the material can be adapted to the characteristics of local students and the conditions of the surrounding environment.

REFERENCES

Anisimova, E. S. (2020). Digital literacy of future preschool teachers. *Journal of Social Studies Education Research*, *11*(1), 230–253.

Azizatunnisa, F., Sekaringtyas, T., Hasanah, U., Pendidikan, F. I., Jakarta, U. N., & Dasar, S. (2022). *Pengembangan Media Pembelajaran Interaktif Game*. *6*(1), 14–23.

Bellaera, L., Weinstein-Jones, Y., Ilie, S., & ... (2021). Critical thinking in practice: The priorities and practices of instructors teaching in higher education. *Thinking Skills and* …. https://www.sciencedirect.com/science/article/pii/S1871187121000717

Chen, J. C. (2022). Developing a cycle-mode POED model and using scientific inquiry for a practice activity to improve students' learning motivation, learning performance, and hands-on …. *Interactive Learning Environments*. https://doi.org/10.1080/10494820.2020.1716023

Ennis, R. (2018). Critical Thinking Across the Curriculum: A Vision. *Topoi*, *37*(1), 165–184. https://doi.org/10.1007/s11245-016-9401-4

Fazio, C., Di Paola, B., & Battaglia, O. R. (2020). A study on science teaching efficacy beliefs during pre-service elementary training. *International Electronic Journal of Elementary Education*, *13*(1), 89–105. https://doi.org/10.26822/iejee.2020.175

Gunawan, G. (2020). Gender description on problem-solving skills in chemistry learning using interactive multimedia. *Journal for the Education of Gifted Young Scientists*, *8*(1), 561–589. https://doi.org/10.17478/jegys.627095

Hasanah, Uswatun, Astra, S. (2023). *Exploring the Need for Using Science Learning Multimedia (SLM) to Improve Critical Thinking Elementary School Students : Teacher*. *16*(1), 1–26.

Hasanah, U. (2021). *IMPLEMENTATION OF ONLINE LEARNING FOR CHILDREN WITH LANGUAGE DISORDER*. *11*(1).

Husein, S. (2021). Problem-Based

http://doi.org/10.31800/jtp.kw.v11n2.p700--715

Learning with Interactive Multimedia to Improve Students' Understanding of Thermodynamic Concepts. In *Journal of Physics: Conference Series* (Vol. 1233, Issue 1). https://doi.org/10.1088/1742-6596/1233/1/012028

Jong, T. de, Gillet, D., Rodríguez-Triana, M. J., Hovardas, T., Dikke, D., Doran, R., Dziabenko, O., Koslowsky, J., Korventausta, M., Law, E., Pedaste, M., Tasiopoulou, E., Vidal, G., & Zacharia, Z. C. (2021). Understanding teacher design practices for digital inquiry-based science learning: the case of Go-Lab. In *Educational technology research and development : ETR & D* (pp. 1–28). https://doi.org/10.1007/s11423-020-09904-z

Lin, X. F., Hwang, G. J., Wang, J., Zhou, Y., Li, W., & ... (2022). Effects of a contextualised reflective mechanism-based augmented reality learning model on students' scientific inquiry learning performances, behavioural patterns …. *Interactive Learning …*. https://doi.org/10.1080/10494820.2022.2057546

Mayer, R. E., & Moreno, R. (1998). Cognitive Theory of Multimedia Learning. *The Cambridge Handbook of Multimedia Learning*, *Mayer*, *R.*, 31–49. http://www.learning-theories.com/cognitive-theory-of-multimedia-learning-mayer.htm

Modlinger, D. (2020). *eLearning und Mobile Learning – Konzept und Drehbuch*. http://books.google.com/books?id=7gk0ksBEVYAC&pgis=1%5Cnhttp://link.springer.com/10.1007/978-3-642-17206-9%5Cnhttp://link.springer.com/10.1007/978-3-642-17206-9

Nippold, M. (2015). Critical thinking about fables: Examining language production and comprehension in adolescents. *Journal of Speech, Language, and Hearing Research*, *58*(2), 325–335. https://doi.org/10.1044/2015_JSLHR-L-14-0129

Pan, Z., López, M. F., Li, C., & Liu, M. (2021). Introducing augmented reality in early childhood literacy learning. *Research in Learning Technology*, *29*(1063519), 1–21. https://doi.org/10.25304/rlt.v29.2539

Pardjono, P. (2020). Multimedia interactive learning of pictorial projection mechanical engineering skills in vocational high schools. In *Journal of Physics: Conference Series* (Vol. 1700, Issue 1). https://doi.org/10.1088/1742-6596/1700/1/012009

Ruth Clack, R. E., & Mayer. (n.d.). *Why is e-Learning and the Science of Instruction*.

Samaniego-Mena, E. (2020). Interactive multimedia as support for the therapy of infants with dyslalia. *Revista de Ciencias Sociales*, *26*(4), 368–379.

http://doi.org/10.31800/jtp.kw.v11n2.p700--715

https://doi.org/10.31876/rcs.v26i4.34668

Stylinski, C. D., Peterman, K., Phillips, T., & ... (2020). Assessing science inquiry skills of citizen science volunteers: a snapshot of the field. *… Journal of Science …*. https://doi.org/10.1080/21548455.2020.1719288

Takaya, K. (2019). Jerome Bruner's theory of education: From early Bruner to later Bruner. *Interchange*, *39*(1), 1–19. https://doi.org/10.1007/s10780-008-9039-2

Tampubolon, T. (2020). The Application of Bruner's Learning Theory on Teaching Geometric at Smp Negeri 2 Sipahutar in Academic Year 2017/2018. *International Journal of Advanced Engineering, Management and Science*, *4*(5), 351–356. https://doi.org/10.22161/ijaems.4.5.1

Urbani, J., Roshandel, S., Michaels, R., & Truesdell, E. (2017). Developing and Modeling 21st-Century Skills with Preservice Teachers. *Teacher Education Quarterly*, *44*(4), 27–50.

William W. Lee, D. L. O. (2004). *Multimedia-based Instructional Design: Computer-based Training, Web-based Training, Distance Broadcast Training, Performance-based Solutions, 2nd Edition*. 488.

Wu, Y. P., Aspinwall, L. G., Nagelhout, E., Kohlmann, W., Kaphingst, K. A., Homburger, S., Perkins, R. D., Grossman, D., Harding, G., Cassidy, P., & Leachman, S. A. (2018). Development of an Educational Program Integrating Concepts of Genetic Risk and Preventive Strategies for Children with a Family History of Melanoma. In *Journal of cancer education : the official journal of the American Association for Cancer Education* (Vol. 33, Issue 4, pp. 774–781). https://doi.org/10.1007/s13187-016-1144-9

http://doi.org/10.31800/jtp.kw.v11n2.p700--715