

Development of DISCA (Digital Smart Card) Learning Media Based on Critical Thinking for Energy Conversion Material in Grade IV Elementary School

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Abstract

The purpose of this research is to create a critical thinking-based instructional media called DISCA (Digital Smart Card) for energy conversion materials that is valid according to subject matter experts, media experts, teachers, practical according to students, and effective in stimulating students' critical thinking skills. This R&D process employs the ADDIE model. The critical thinking-based DISCA refers to Facione with indicators adapted to Piaget's cognitive development for fourth-grade elementary school, which include analysis, evaluation, and explanation. The results showed that the product received average percentage of 93.75% indicating a "very valid" category. In practicality with average percentage of 98.8% categorized as "very practical." The effectiveness in stimulating critical thinking skills using the N-Gain Score showed that it was with a score of 80,19% indicating an "effective". These research, it can be concluded that the DISCA for energy conversion materials for fourth-grade elementary school students is considered very valid, considered very practical, effective in stimulating critical thinking.

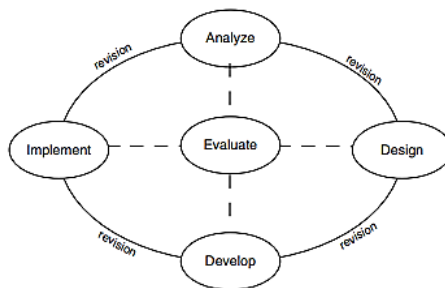
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1. Introduction

Under the title "Development of DISCA (Digital Smart Card) Learning Media Based on Critical Thinking for Energy Conversion Material in Grade IV Elementary School," research and development of engaging learning media are necessary. The absence of card-based learning media to stimulate critical thinking skills in energy conversion material for fourth-grade students makes this research and material development crucial. The objective of this research and development is to create DISCA learning media based on critical thinking in science subjects, specifically energy conversion, which is valid, practical, and effective in stimulating critical thinking skills. This research aims to benefit both teachers and students. Teachers can assist students in learning in an engaging and practical manner, encouraging critical thinking, particularly in the topic of energy conversion material.

2. Method

Development of DISCA learning media based on critical thinking for energy conversion material in Grade IV elementary school uses the Research and Development (R&D) model. R&D focuses on continuously improving the quality of a specific product or service, leading to new innovations (Ardiani, 2022). ADDIE is an acronym for the phases: analysis, design, development, implementation, and evaluation. The ADDIE development model used in the research and development of DISCA is illustrated in Figure 1 below.



Picture 1. Step of ADDIE Development

The research design within the ADDIE framework begins with curriculum analysis of the Merdeka curriculum, focusing on IPAS learning outcomes in energy conversion and integrating findings from literature reviews on students' critical thinking skills. This process yields learning objectives for critical thinking based on Facione's analysis, evaluation, and explanation indicators. Subsequently, planned media is designed using various software tools including ClassPoint AI, PowerPoint, interactive applications, Canva for editing, and a QR code generator. Following the revised design of the DISCA media, it is developed based on consultations with experts and further revisions to ensure suitability for implementation in overall implementation trial of the media will include evaluation stages conducted throughout each phase: analysis, planning, development, and implementation.

This approach ensures that assessment and feedback occur continuously, allowing for adjustments and improvements as necessary at each stage of the process. Evaluation during these phases helps gauge the effectiveness of the DISCA media in meeting its objectives and ensures it aligns with the critical thinking skills development goals identified earlier. It also allows for any necessary revisions based on insights gained from the evaluation, ensuring the final implementation is well-prepared and effective.

3. Results and Discussion

3.1 Result

Results of the research and development were conducted with the aim of producing DISCA (Digital Smart Card) media based on critical thinking for energy conversion material that is valid, practical, and effectively stimulates critical thinking skills. The developed product was validated by experts as shown in Picture 2 and 3 below.



Picture 2. Show of DISCA Interactive in Pps File for Students



Picture 3. Shown of DISCA Printable with QR-Code

Based on the developed product, steps were taken to achieve the research and development objectives. The elaboration of each analysis is as follows:

Product Validity: The DISCA product based on critical thinking for energy conversion material underwent validation stages by subject matter experts, media experts, and users (teachers). The summary of product validation results is presented in Table 1 below.

Table 1. Result of Product Validity

No.	Assessment Aspect	Maximum Score	Assessment			Average	Category
			Material Expert	Media Expert	User (Teacher)		
1.	Content of material	4	3	-	4	87,5%	Very valid
2.	Material coverage	4	4	-	3	87,5%	Very valid
3.	Systematic presentation	4	4	-	4	100%	Very valid
4.	Language	4	4	-	4	100%	Very valid
5.	Product presentation	4	-	4	4	100%	Very valid
6.	Application of DISCA (Digital Smart Card)	4	-	4	4	100%	Very valid
7.	Product use	4	-	3	4	87,5%	Very valid
8.	Product operational	4	-	4	4	100%	Very valid
Score			15	15	30		
Total Score			60				
Average Percentage			93,75%				
Overall Category			Very valid				
Test Decision			Can be used without revision				

Based on Table 1, the results of product validity analysis show an average score of 93.75. Referring to Akbar's categorization criteria (2017), this is classified as highly valid. The DISCA product based on critical thinking for energy conversion material is concluded to be highly valid and suitable for educational use. The validity scores for each aspect of the DISCA product

are as follows: content reached a score of 87.5%; coverage aspect achieved a validity score of 87.5%; presentation systematicity aspect scored 100%; language aspect received a highly valid score of 100%; product presentation aspect achieved a maximum score, hence 100% percentage; DISCA application aspect obtained a validity score of 100%; product usage aspect scored 87.5%; and product operation aspect achieved a validity score of 100%.

Following the product validation stage, feedback and suggestions were received from subject matter experts, media experts, and users (teachers). Based on this feedback, an evaluation process was conducted which involved revising the product to ensure it was suitable before testing it in the research process. After revision, the product underwent testing in the form of media application trials, practicality questionnaire responses from students, and pre-test and post-test implementations to assess the effectiveness of improving critical thinking skills among students.

Practicality of the Product: The DISCA learning media product based on critical thinking for energy conversion material developed and validated was measured for its practicality based on student questionnaire responses. The respondents in the practicality questionnaire numbered 27 students. The results of the student practicality questionnaire responses are presented in Table 2 below.

Table 2. Results of Filling Out the Practicality Questionnaire by Students

No.	Indicator	Score	Percentage
1.	Instructions for using the media are clear and easy to understand	27	100%
2.	The product can be used without special skills	27	100%
3.	The product is easy to use and access	25	92%
4.	The product makes it easy to understand energy conversion materials	27	100%
5.	Products can increase insight and knowledge	26	96%
6.	The product makes students active in learning	27	100%
7.	Character images, writing and media application illustrations are clear and attractive	27	100%
8.	Can be used again outside of learning hours	27	100%
9.	Able to increase enthusiasm for learning while playing	27	100%
10.	Provide enthusiasm for practicing questions through interactive games and feedback	27	100%
Amount		267	988%
Average		98,8%	
Category		Very practical	
Information		Can be used without revision	

Based on Table 2, the survey data on the practicality of DISCA-based critical thinking learning media for Grade IV elementary school students in energy conversion material shows a practicality rate of 98.8%. This figure falls under the category of very practical according to the classification in Table 1. The DISCA-based critical thinking learning media product for Grade IV energy conversion material can be considered highly practical and can be used without revisions. Students are enthusiastic about using this DISCA-based critical thinking learning media in their studies and are eager for other subjects to also utilize similar DISCA media.

There are areas where practicality indicators are not yet optimal or are moderate, specifically in indicators (3) and (5). For indicator (3), students still struggle somewhat with operational instructions in product features, resulting in a practicality score of only 92%. Similarly, for indicator (5), in its implementation, students have not fully felt the effects of increased insight and knowledge. Based on field observations, class teachers as observers note

that students are active in application but continuous involvement does not guarantee overall insight gains. This highlights the need for internalization and habitual use so that students can truly experience increased insight in real-life contexts.

Product Effectiveness: The purpose of testing the effectiveness of this product is to assess how effective DISCA-based critical thinking learning media on energy conversion material is in stimulating students' critical thinking skills. The effectiveness data analyzed here are based on pre-test and post-test results. Effectiveness testing involves prerequisite tests (normality and homogeneity), N-Gain Score test, and T-test (Paired Sample T-test).

In the normality test using Kolmogorov-Smirnov, a significance value of 0.2 was obtained. A value of 0.2 falls under the category of significance > 0.05, indicating that the data is normally distributed. This is illustrated in Figure 4.

One-Sample Kolmogorov-Smirnov Test

		Unstandardized Residual
N		27
Normal Parameters ^{a,b}	Mean	.0000000
	Std. Deviation	11.98754960
Most Extreme Differences	Absolute	.137
	Positive	.137
	Negative	-.114
Test Statistic		.137
Asymp. Sig. (2-tailed)		.200 ^{c,d}

Picture 4. Result of Normality Test

In the homogeneity test using Levene's test, a significance value of 0.438 was obtained. With a significance value of 0.438, which falls under the category of significance > 0.05, it can be concluded that the data exhibits homogeneity. This is further illustrated in Figure 5.

Test of Homogeneity of Variances

		Levene Statistic	df1	df2	Sig.
Belajar IPAS IV	Based on Mean	.611	1	52	.438
	Based on Median	.347	1	52	.558
	Based on Median and with adjusted df	.347	1	51.230	.558
	Based on trimmed mean	.556	1	52	.459

Picture 5. Result of Homogeneity Test

The analysis proceeds with descriptive statistical analysis of students' critical thinking skills in the indicators of analysis, evaluation, and explanation by dissecting the achievement results from both the pre-test and post-test for each respective indicator. Based on the three critical thinking indicators, each was further developed into two learning objectives for energy conversion. Subsequently, a set of questions corresponding to each objective were developed, resulting in twelve multiple-choice items for the pre-test and post-test.

In this descriptive statistical analysis, the N-Gain Score test is also conducted. The descriptive statistical analysis of critical thinking skills and the N-Gain Score test results are presented in Table 3 below.

Table 5. Descriptive Statistics of Critical Thinking Skills

No.	Indicator	Pre-test		Post-test		N-Gain (%)	Interpretation Category
		M	SD	M	SD		
1.	Analysis	23,67	5,02	31,30	3,16	82,71	Effective
2.	Evaluation	22,50	5,43	31,30	3,16	85,27	Effective
3.	Explanation	20,00	4,30	31,30	4,28	72,60	Effective enough
Average		22,04	3,35	31,30	2,13	80,19	Effective

Based on Table 3, the analysis of pre-test and post-test results using mean statistics indicates an overall increase in the mean post-test scores for each critical thinking indicator (analysis, evaluation, and explanation) compared to the mean pre-test scores. The standard deviation (SD) values in the post-test indicators have decreased compared to those in the pre-test indicators. This suggests that, on average, students showed improved learning outcomes after using the DISCA media, with the post-test data aligning more closely with the mean pre-test data from the statistical sample.

The N-Gain Score test results for critical thinking indicators are as follows:

- a. For the analysis indicator, the percentage score is 82.71%, categorizing it as effective.
- b. For the evaluation indicator, the score is 85.27%, indicating high effectiveness compared to other indicators.
- c. For the explanation indicator, the score is 72.60%, categorized as moderately effective.
- d. The average effectiveness score for critical thinking N-Gain Score is 80.19%, falling under the effective category.

According to the effectiveness interpretation categories in Table 2, it can be concluded that there is an effective influence in stimulating critical thinking skills at the analysis and evaluation levels, and a moderately effective influence at the explanation level among students using DISCA-based critical thinking learning media for energy conversion material.

Next, a Paired Sample T-test was conducted based on paired pre-test and post-test data for each critical thinking indicator (analysis, evaluation, and explanation). The results include hypothesis testing data such as t-values, degrees of freedom (df), and probabilities, presented in Table 6 as follows.

Table 6. Paired Sample T-test Results Pre-test and Post-test Critical Thinking Skills

No.	Indicator	t	df	p
1.	Analysis	7.879	26	0.000
2.	Evaluation	8.716	26	0.000
3.	Explanation	10.196	26	0.000
Effectivity of Critical Thinking		15.031	26	0.000

The analysis of pre-test and post-test results using the Paired Sample T-test, as presented in Table 6, shows that the probability of the test results aligning with the hypothesis—that there is a significant change between pre-test and post-test scores—is generally confirmed (with a significance level of $p = 0.000$, which is less than 0.005). This indicates a statistically significant improvement in students' critical thinking skills across all tested indicators: analysis, evaluation, and explanation. Therefore, it can be concluded that DISCA-based critical thinking learning media for energy conversion material effectively enhances students' critical thinking skills.

3.2 Discussion

Based on needs analysis and initial analysis activities through interviews, there is a requirement for digital learning media capable of stimulating critical thinking skills in energy conversion topics. Quoting Facione (in Demirhan & Köklükaya, 2014), critical thinking involves independent self-regulated judgment aimed at interpreting, analyzing, evaluating, making inferences, and explaining evidence, conceptual methodologies, setting criteria, or contextual considerations. Facione (2015) identifies six indicators of critical thinking, each with operational verbs adapted into Indonesian as follows: (1) interpretation with operational verbs categorisation (grouping), decoding significance (decoding), and clarifying meaning (explaining meaning); (2) analysis with operational verbs examining ideas (testing ideas), identifying arguments (recognizing arguments), and analyzing arguments (identifying reasons and statements); (3) evaluation with operational verbs assessing claims (assessing statement claims) and assessing arguments (evaluating argument quality); (4) explanation with operational verbs stating results (stating results), justifying procedures (supporting procedures), and presenting arguments (presenting arguments); (5) inference with operational verbs querying evidence (questioning evidence), conjecturing alternatives (assuming alternatives), and drawing conclusions (drawing conclusions using inductive and deductive considerations); and (6) self-regulation with operational verbs self-examination (self-monitoring) and self-correction (self-improvement) (Alsaleh, 2020).

According to Alsaleh (2020), achieving consensus on Facione's definition of critical thinking is supported by the participation of researchers and teachers in the American Philosophical Project Delphi Association, which indicates that characteristics of critical thinkers include curiosity, fairness, flexibility, diligence, and a focus on investigation. In contrast, Putri et al. (2023) argue that critical thinking does not stand alone but is integrated with higher-order thinking skills (HOTS). Despite appearing contradictory to Facione's theory, which views critical thinking as an independent skill, the main goal remains the same: stimulating students to engage in detailed, complex thinking, such as critically analyzing new information, thinking creatively when faced with challenges, and strategizing in complex decision-making situations.

Based on Piaget's cognitive development theory, elementary school Grade IV children have reached the concrete operational stage. In Piaget's theory, learning adaptation involves developing schemas through direct interaction with the environment. This means Grade IV student The need for concrete learning media objects from their environmental scope is highlighted in line with Dewi's statement (2021) that a medium in education helps facilitate students to quickly understand abstract material into concrete or tangible concepts. Therefore, critical thinking indicators that need to be developed in concrete learning to support the concrete operational cognitive phase of Grade IV students include analysis, evaluation, and explanation.

The Digital-based Flash Card to Increase Social Studies Learning Outcomes for Elementary School Students in the Fourth Grade, as researched and developed by Sudrajat et al. (2023), provides references on the flexibility of digital media such as flashcards, which have a significant impact on aiding learning. Digital media applications play a dual role in achieving learning objectives and internalizing the digitalization of learning. The application of digital media in the form of flashcards facilitates learning for students, stimulates learning motivation, and constructs knowledge critically. DISCA media utilizes this role. The development of flashcard media assisted by QR codes has been tested in Wulandari's study

(2023) with the aim of enhancing student learning outcomes and producing both validity and practicality tests. This serves as a reference for the important role of technology adaptation incorporated into print products, thereby providing brainstorming effects to explore new information with students' smartphones. The presentation of QR codes and their complementary features in DISCA collaborates effectively to support its use.

Critical thinking skills tested based on Facione's critical thinking theory include three indicators: analysis, evaluation, and explanation. Generally, all three indicators show improvement after implementing DISCA media in education. The breakdown of the analysis of effectiveness results for each indicator is as follows:

- a. The analysis indicator is broken down into two learning objectives, each utilizing Facione's operational verbs:
 - 1) Through identification activities and literature studies, students can correctly identify the meaning of energy from factual problems encountered.
 - 2) Through analysis activities around the classroom and school environment, students can present project results of several energy-saving efforts based on examples of energy-using objects analyzed critically. Based on the learning objectives, the analysis was analyzed from the pre-test and post-test results with statistical tests in Table 5 showing an increase from an average pre-test analysis skill level of 23.67 to 31.30 in the average post-test analysis. The effectiveness of critical thinking skills in the analysis level was tested using the N-Gain Score, with a percentage result of 82.71%, interpreted as effectively stimulating critical thinking skills at the analysis level.
- b. The evaluation indicator is broken down into two learning objectives, each using Facione's operational verbs:
 - 1) Through group discussion activities, students can analyze the relationship of arguments from the concept of the law of energy conservation critically.
 - 2) Through team game activities, students can test their arguments regarding the energy form conversion process from the trial of energy card games critically. The evaluation skills also improved from an average pre-test evaluation skill level of 22.50 to 31.30 in the average post-test evaluation. The effectiveness of critical thinking skills at the evaluation level was also tested using the N-Gain Score, obtaining a percentage result of 85.27%, interpreted as effectively stimulating critical thinking skills at the evaluation level as the highest achiever among the three indicators tested.
- c. The explanation indicator is broken down into two learning objectives:
 - 1) Through team game activities, students can prove to their friends about concrete energy sources from the trial of energy card games cooperatively.
 - 2) Through team game activities, students can communicate the results of their argument test regarding the energy form conversion process from the trial of energy card games critically. Explanation skills increased from an average pre-test explanation skill level of 20.00 to 31.30 in the average post-test explanation. The effectiveness of critical thinking skills at the explanation level was also tested using the N-Gain Score, obtaining a percentage result of 72.60%, interpreted as sufficiently effective in stimulating critical thinking skills at the explanation level. The average effectiveness results of the three indicators reached 80.19%, categorized as effective.

The indicator with the highest effectiveness achievement in applying DISCA media is evaluation. The operational verbs in the evaluation applied in DISCA media include assessing claims and assessing arguments, as reflected in the learning objectives (Alsaleh, 2020). Its

implementation form includes claiming the energy conversion process statement from the phenomenon image in DISCA and testing arguments regarding the energy form conversion process from several possible stages of the misleading energy card DISCA critically. Factors supporting the improvement of critical thinking skills from the observation results of media application are derived from each discussion stimulated by questions or stimulating images and free cards in DISCA print as student brainstorming stimuli to digest their understanding, thus forming early thinking stimuli in students (Nilah & Roza, 2020). Several materials are associated with each question that explicitly stimulates the discovery of meaning and deceives students to analyze appropriate arguments and evaluate their accuracy.

Based on the analysis in this research and development, novelty is found in the development of analysis, evaluation, and explanation skills through assessments that stimulate students to make arguments or predictions based on free cards. Free cards in DISCA have the value of stimulating students' analysis skills according to the image of the card. The analysis stimulus occurs when students classify selected cards randomly to find the right card as needed for assessment. Students' evaluation skills are stimulated in activities to find the order of the energy conversion process. Explanation skills are also stimulated by helping students to communicate their arguments in a structured manner based on the sequence of free cards successfully arranged.

This research and development still have limitations in the form of digital function limitations limited to interactive applications. The development of DISCA products can be digitally animated games that can correlate directly with Facione's critical thinking skills. For example, the development of assessment tests synchronized gradually from the interpretation level to self-regulation. Each discussion (feedback) is not only integrated through QR codes with teaching materials but also developed in new discovery learning involving student experiments directly. This further development can be further developed more excellently by prioritizing stimulation of critical thinking skills in students.

4. Conclusion

Based on the discussion regarding the research and development outcomes of the DISCA (Digital Smart Card) product based on critical thinking for Grade IV elementary school energy conversion material, it is concluded that the validity of the product has been affirmed by media experts, subject matter experts, and practitioners (teachers). The results from student questionnaire responses regarding practicality indicate that the product is categorized as highly practical. Additionally, there are effective analysis results of critical thinking skills based on N-Gain Score testing across the three critical thinking indicators: analysis, evaluation, and explanation. These results categorize the product as effective in stimulating critical thinking skills in students. Therefore, the product produced meets the objectives of the research and development.

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