

Development of IPAS Teaching Materials with the RADEC Model Based on Metacognitive Strategies to Enhance Critical and Creative Thinking Skills

Jumanto^{1*}, Udin Syaefudin Sa'Ud¹, Wahyu Sopandi¹

¹Elementary Education, Universitas Pendidikan Indonesia, Bandung, Indonesia

Received: January 19, 2024

Revised: February 25, 2024

Accepted: March 25, 2024

Published: March 30, 2024

Corresponding Author:

Jumanto

antokarof@gmail.com

DOI: [10.29303/jppipa.v10i3.7010](https://doi.org/10.29303/jppipa.v10i3.7010)

© 2024 The Authors. This open access article is distributed under a (CC-BY License)



Abstract: The purpose of this study is to develop IPAS teaching materials using the RADEC model based on metacognitive strategies to enhance critical and creative thinking skills among elementary school students. The research follows the Research & Development approach with the ADDIE development model (Analysis, Design, Development, Implementation, Evaluation). The study involves 84 elementary school students in Surakarta. Data were collected through literature review, expert validation, pretests and posttests, observations, interviews, and documentation. Validation results confirmed that the developed book is valid and suitable for use in terms of content, language, and presentation. A paired sample T-test was conducted on the pretest and posttest results of critical and creative thinking skills for 84 student respondents. The t-test results indicated a significance value of $0.00 < 0.05$ for both pretest and posttest scores of critical thinking skills and creative thinking skills. This suggests a significant difference in the average scores between the pretest and posttest, indicating the influence of the developed book on critical and creative thinking skills. The N-Gain test results for pretest and posttest scores of critical thinking skills were 70.9252, and for creative thinking skills, it was 70.9284. With these values, it can be concluded that the developed book falls into the category of being sufficiently effective in influencing the critical and creative thinking skills of students.

Keywords: Creative Thinking; Critical Thinking; Elementary School; Metacognitive Strategies; RADEC.

Introduction

The rapid development of technology and information in the 21st century has impacted various aspects of life, including education (Mardhiyah et al., 2021). Formal education processes must adapt and evolve to equip students with competencies or skills relevant to the 21st century. 21st-century competencies are the skills needed by students to support the learning process, adapt to changes, and face the challenges, issues, and careers of the 21st century (Ongardwanich et al., 2015; Redhana, 2019).

The Ministry of Education and Culture of Indonesia responds to the demands of the 21st century by placing more emphasis on efforts to improve students' thinking

skills. Clearly stated in the appendix of Minister of Education and Culture Regulation number 21 of 2016, there are four important aspects to be enhanced: spiritual attitudes, social attitudes, knowledge, and skills. In the skills aspect, it is further detailed into several thinking skills, including creative, critical, productive, independent, and collaborative thinking (Lampiran Permendikbud Nomor 21 Tahun 2016, 2016). This regulation is reinforced by Minister of Education and Culture Regulation number 22 of 2020, which regulates the six characteristic dimensions that students must possess called the Profil Pelajar Pancasila, consisting of: Believing and being devoted to God Almighty and having noble morals, global diversity, cooperation, independence, critical thinking, and

How to Cite:

Jumanto, J., Sa'Ud, U.S., & Sopandi, W. (2024). Development of IPAS Teaching Materials with the RADEC Model Based on Metacognitive Strategies to Enhance Critical and Creative Thinking Skills of Elementary School Students. *Jurnal Penelitian Pendidikan IPA*, 10(3), 999-1007. <https://doi.org/10.29303/jppipa.v10i3.7010>

creativity (Permendikbud Nomor 22 Tahun 2020, 2020). The dimensions of creative and critical thinking skills within the Profil Pelajar Pancasila are expected to meet the demands of current 21st-century education.

Creative thinking skills are essential for individuals to solve problems from various perspectives, enabling them to face complex situations in their surrounding society (Treffinger & Isaksen, 2005). Creative thinking is a thought process that leads to the emergence of new ideas, perspectives, approaches, and methods in understanding something (Awan et al., 2019). Armed with creative thinking abilities, students can address problems through various problem-solving methods (Wanelly & Fauzan, 2020). Commonly, indicators of creative thinking skills consist of fluency, flexibility, originality, and elaboration (Aulia, 2023). However, the Indonesian Ministry of Education has specifically outlined the elements of creative thinking that Indonesian students should possess, which vary at each stage. Fourth-grade elementary school students belong to Phase B, and the elements of creative thinking they should have include: (1) Generating original ideas, (2) Creating original works and actions, and (3) Having flexible thinking in seeking alternative problem solutions (Kemendikbudristek, 2022).

In addition to creative thinking skills, students are also expected to have critical thinking skills. Critical thinking skills involve the ability to understand, analyze, and evaluate information, making it useful for making reasoned and rational decisions. Numerous studies have explored critical thinking abilities, spanning from elementary to higher education levels (O'Reilly et al., 2022). This is because research related to critical thinking has pedagogical implications and offers solutions for critical thinking development (Liang & Fung, 2020). Critical thinking skills enable individuals to have strong, resilient thinking that is not easily swayed by their surroundings (Fardani & Surya, 2017). Thinking critically allows individuals to be open to all existing facts, enabling them to make decisions based on logical evidence (Haryanti, 2017) and helping students sharpen their experiences (Stephanou & Mpiontini, 2017). Critical thinking is highly demanded in the 21st century, as it allows individuals to understand complex problems, connect and consider information from various perspectives, leading to the emergence of various solutions for problem-solving and decision-making in daily life (Musa'ad & Suparman, 2023; Rahmawati et al., 2023; Ulfa, 2020). Instilling critical thinking skills in students can be a comprehensive educational innovation to meet the demands of the 21st century (Manassero-Mas et al., 2022).

Efforts to enhance critical and creative thinking skills can be made through improvements in the education system, at least on a micro level (within a single learning system by a teacher in a classroom). To

carry out teaching that can improve critical and creative thinking skills, supportive teaching materials are essential. Therefore, this study aims to develop IPAS teaching materials using the RADEC model (Read-Answer-Discuss-Explain and Create) based on metacognitive strategies to enhance critical and creative thinking skills in elementary school students.

The RADEC model was chosen because its syntax requires learners to conduct an assessment by reading and answering questions before face-to-face learning activities take place. This encourages learners to prepare before face-to-face learning is conducted (Sopandi, 2017). Moreover, numerous studies have proven that the RADEC model has a positive impact on concept-oriented learning outcomes (Lukmanudin, 2018; Setiawan et al., 2019, 2020; Siregar et al., 2020). It has a positive effect on students' pedagogical competence (Sopandi & Handayani, 2019), positively impacts high-level thinking skills and creative thinking skills (Agustin et al., 2021; Handayani et al., 2019; Jumanto et al., 2018; Ma'ruf et al., 2020; Pratama et al., 2020), and positively affects critical thinking skills (Sapitri et al., 2023; Susanti et al., 2023; Vitriasari et al., 2023). Even with the RADEC syntax that can be performed independently or in groups by learners, it is effectively applied in online learning during the COVID-19 pandemic (Rahman et al., 2020).

The metacognitive strategy is chosen because, with this strategy, learners will be trained to understand their own thinking processes. This is expected to cultivate habits of planning, monitoring, and evaluating their learning processes. Moreover, numerous studies have demonstrated that the metacognitive strategy has a positive impact on students' critical thinking skills (Hasanuddin et al., 2020; Hendi et al., 2020), positive effects on creative thinking skills (Irawan, 2020), positive impacts on communicative abilities (Fauzan et al., 2020; Piadi, 2017), positive effects on students' self-directed learning and attention to learning (Sunanto & Asyiah, 2018; Yasir, 2020), and positive effects on concept understanding (Khoiriah, 2015; Soinbala & Mulyatna, 2019; Virgia et al., 2019).

Based on the problems and needs outlined above and considering previous research, this study aims to develop IPAS teaching materials for fourth-grade elementary school. The teaching materials are developed based on the syntax of the RADEC model using metacognitive strategies to train students' critical and creative thinking skills. This research is important because there is currently no IPAS teaching material in the Merdeka curriculum specifically developed to train students' critical and creative thinking skills. Additionally, teachers need teaching materials that technically facilitate the implementation of the RADEC model because this model has been proven to enhance students' critical and creative thinking skills.

Method

The research method employed is Research and Development using the ADDIE model, consisting of the Analyze, Design, Development, Implementation, and Evaluate stages (Branch, 2009).

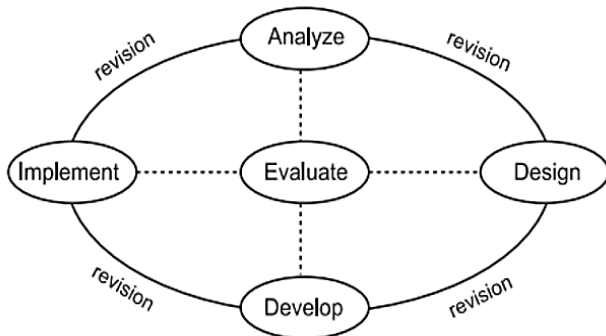


Figure 1. ADDIE development model chart

The analysis phase was carried out in four ways: conducting interviews with 10 fourth-grade elementary school teachers, administering tests on critical and creative thinking skills to 119 fourth-grade elementary school students, examining the current curriculum documents in Indonesia known as "Kurikulum Merdeka," and analyzing the developmental aspects of the participants as the research sample. The Design stage, a systematic and specific instructional material draft is created, considering the appropriateness of content, language, appearance, as well as the model and learning strategies used. The Development stage includes validating instructional materials regarding content, language, and appearance, followed by limited trials in one classroom. The Implementation stage involves applying the instructional materials on a broader scale, with three classes, to gather data on practicality and the effectiveness of the developed student book. The final stage, Evaluate, is conducted by revising the instructional materials based on practicality questionnaires, student responses, and field notes.

The population in this study consists of elementary school students in the city of Surakarta. The sample for this research comprises fourth-grade students from 5 elementary schools in Surakarta that implement the Kurikulum Merdeka. Below is the list of the five schools used for the research:

Table 1. Research Sample Schools

School	Role in the Research
SDN Gandekan	Small-scale Test
SDN Madyotaman	Small-scale Test
SDN Kestalan	Large-scale Test
SDN Mojosongo	Large-scale Test
SDN Joglo	Large-scale Test

This research employs three data collection techniques. Interview technique is used to obtain data during needs analysis and development stages. Questionnaire technique is used to gather expert validation data on the developed product and the practicality level of the product. Test technique is used to obtain initial data on students' critical thinking and creative thinking skills and to measure the effectiveness of the product through pretests and posttests.

This research utilizes three data collection instruments: (1) Interview guidelines for elementary school teacher needs; (2) Questionnaire sheets for content validation, display validation, language validation, and practicality questionnaire; (3) Tests of critical thinking and creative thinking skills.

Data is analyzed both qualitatively and quantitatively. Qualitative analysis is conducted to process data from interview guidelines and questionnaire sheets, summarizing the data into descriptive information. Quantitative analysis is conducted to process data from questionnaires and tests, revealing the quality, practicality, and effectiveness of the developed product.

Result and Discussion

Analysis of needs was conducted through interviews with 10 fourth-grade teachers in elementary schools in Surakarta and tests on critical thinking and creative thinking skills for 119 fourth-grade students in Surakarta. Based on the interview results, it was found that 80% of teachers still faced difficulties teaching critical thinking skills, and 70% of teachers encountered challenges in teaching creative thinking skills. The test results for critical thinking skills revealed that 59% of students had low-level critical thinking skills, 25% had moderate-level skills, and 16% had high-level skills. Meanwhile, based on the test results for creative thinking skills, it was found that 64% of students had low-level skills, 20% had moderate-level skills, and 17% had high-level skills.

Table 2. Critical and Creative Thinking Skills of Students

Skill Level	Critical Thinking Skill (%)	Creative Thinking Skill (%)
High	16	17
Moderate	25	20
Low	59	64
Total	100	100

The interviews also revealed that teachers required instructional materials with a systematic approach to train both critical and creative thinking skills in students. The analysis continued by examining the current curriculum document in Indonesia, known as "Kurikulum Merdeka" (Independent Curriculum). Through a review of the document, it was identified that

the components of critical and creative thinking skills to be developed for fourth-grade elementary school students had been specified in the regulation SK BSKAP number 009/H/KR/2022. This regulation addresses character education in the Kurikulum Merdeka, referred to as the "Profil Pelajar Pancasila" (Pancasila Student Profile). The regulation outlines the components of critical and creative thinking skills to be developed for students, mentioning elements and sub-elements within the dimensions of critical and creative reasoning.

Based on the analysis of student development aspects, it was found that fourth-grade students fall within the age range of 8-10 years. Therefore, according to the Kurikulum Merdeka, they belong to phase B. With this information, the elements and sub-elements of critical and creative reasoning that should be taught to fourth-grade students can be determined.

Tahap design involved creating a draft of the Student Book systematically and specifically, considering the aspects of content appropriateness, language, presentation, models, and teaching strategies. The book's structure included a cover, preface, table of contents, learning objectives, studied materials along with activities, material summaries, evaluations, bibliography, and appendices. The book was specifically designed for fourth-grade elementary school students in the subject of IPAS with a focus on the topic of Energy and Its Changes. The creation of the book also considered content appropriateness by aligning the book's content with the learning outcomes in the Merdeka curriculum specified in the regulation SK BSKAP number 033/H/KR/2022. Language and presentation aspects were also considered by adapting to the developmental stage of fourth-grade students, who are still in the operational concrete stage. The book was designed with the RADEC model, incorporating Read-Answer-Discuss-Explain and Create stages. It was developed based on the metacognition strategy, incorporating planning, monitoring, and evaluation in each RADEC stage.

In the development phase, the instructional material underwent validation for content, language, and presentation, followed by limited trials in one class. The results of the validation by experts on content, language, and presentation are presented in Table 3.

The expert validation results indicated that the developed student book received a score of 4.8 out of a maximum scale of 5 for the content aspect. The validator stated that the book was suitable for use with minor revisions. The suggestion from the validator was to add real-life examples to the material summary to make it more comprehensive and include additional visual images relevant to the material. Furthermore, the results of the linguistic expert validation can be seen in the Table 4.

Table 3. Expert Validation on Content Aspect

Assessed Content Aspect	Score
Suitability with the curriculum	
Lists appropriate learning objectives	5
Material aligns with learning objectives	5
Completeness of material	
Provides complete explanations of concepts/ definitions	5
Material includes examples of real-life cases	5
Material includes summaries	4
Clarity of material	
Material is presented systematically	5
Material is explained using clear terminology	5
Visual illustrations support the clarity of the material's concepts	4
Quality of material content	
Explanations of concepts/ definitions/ material are correct	5
Real-life examples or events in the book are accurate	5
Average Score	4,8

Table 4. Expert Validation on Language Aspect

Assessed Content Aspect	Score
Communicative	
Sentence structure in paragraphs is interconnected and supports one main idea	5
Sentences are easy to understand	5
Dialogical - Interactive	
Uses sentences that engage the reader	5
Clarity	
Word choices have a single meaning	5
Coherence	
Concepts are presented in a logical and interconnected manner	5
Correctness of Language Norms	
Spelling is accurate	4
Correct use of punctuation	4
Sentences are structured correctly	4
Use of Terms and Symbols	
Accuracy in the use of terms and symbols	5
Consistency in the use of terms and symbols	4
Average Score	4,6

The expert validation results for the language aspect indicated that the developed student book received a score of 4.6 out of a maximum scale of 5. The validator stated that the book was suitable for use with minor revisions. The suggestions from the validator included correcting some spellings, improving punctuation use, refining sentence structures, and ensuring consistency in addressing the reader as "kamu" and "kalian." Furthermore, the results of the learning media expert validation can be seen in Table 5.

Table 5. Validation of learning media experts

Assessed Content Aspect	Score
Suitability	
Design aligns with students' developmental stage	5
Book aligns with Merdeka curriculum	5
Book design aligns with presented material	5
Book includes RADEC model steps	5
Book includes metacognition strategy components	5
Display Quality	
Good cover design	5
Good interior design	4
Proper font selection	4
Good color design	4
Good image design	5
Average Score	4,7

The results of the validation by the instructional media expert indicate that the student book developed has a score of 4.7 out of a maximum scale of 5 in terms of appearance and suitability. The validator stated that the book is deemed suitable for use with minor revisions. Suggestions from the validator include the need for markers, such as bolded fonts for important material that students should understand. Additionally, font selection should be changed for better readability, and the addition of color variations to make the book more engaging and legible.

After receiving validation and revisions, the student book developed was subjected to limited testing in one class. This trial aimed to assess the book's usability as a teaching material in the classroom. The results of the limited trial indicated that the book could be easily and smoothly used by students. According to interviews, teachers found it very helpful in teaching the material while simultaneously cultivating critical and creative thinking skills. Additionally, students enjoyed the stories and activities presented in the developed book.

The implementation phase involved applying the teaching materials on a broader scale, specifically in three classes, to gather data on practicality and the effectiveness of the developed student book. Practicality data were obtained from questionnaires filled out by 84 students from three different schools. The questionnaire results revealed a total practicality score of 6950, with an average score of 82.74. This categorizes the developed book as "Practical." The distribution of practicality data from the 84 respondents is as Table 6.

Table 6. Book Practicality Data

Criteria	Number of Respondents	Percentage of Respondents (%)
Very Practical	43	51.19
Practical	30	35.71
Moderately Practical	11	13.10
Less Practical	0	0.00
Very Less Practical	0	0.00

The results demonstrate that the developed book is perceived as practical by the majority of respondents, emphasizing its usability and effectiveness in a classroom setting

To determine the effectiveness of the developed book, pretests and posttests on critical and creative thinking skills were administered to 84 students from three different groups. The evaluation process involved normality tests, paired sample t-tests, and N-Gain tests. The normality test results are provided in Table 7.

Table 7. Normality Test for Critical Thinking Skills Data

	Group	Statistic	Shapiro-Wilk	
			df	Sig.
Critical Thinking	Group 1	.911	28	.021
	Group 2	.935	28	.084
	Group 3	.915	28	.026

Table 8. Normality Test for Creative Thinking Skills Data

	Group	Statistic	Shapiro-Wilk	
			df	Sig.
Creative Thinking	Group 1	.911	28	.021
	Group 2	.920	28	.034
	Group 3	.915	28	.026

Based on the two tables above, it is evident from the Shapiro-Wilk significance column that the values are greater than 0.05. This indicates that both sets of data are normally distributed. With the confirmation of normal distribution, the analysis can proceed with the paired sample T-test.

The paired sample T-test was conducted to assess the impact of using the developed book on the critical and creative thinking skills of the 84 students. The results are outlined in the Table 9.

Table 9. Paired Samples Test for Critical Thinking Skills

	Paired Differences			t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean			
PreTest - PosTest	-38.929	5.547	.605	-64.32	83	.000

Table 10. Paired Samples Test for Creative Thinking Skills

	Paired Differences			t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean			
PreTest - PosTest	-38.92	5.863	.640	-60.84	83	.000

In both tables, the significance values (Sig. < 0.05) suggest a significant difference in average scores between the pretest and posttest. This implies that the utilization of the developed book has a considerable impact on enhancing critical and creative thinking skills.

The analysis continues with an examination of the book's effectiveness.

To evaluate the effectiveness of the book on students' critical and creative thinking skills, an NGain test was performed. The results are presented in the table below.

Table 11. NGain Test

	Thingking skills	N	Mean	Std. Deviation	Std. Error Mean
NGain_	Critical	84	70.925	9.90801	1.08105
Percent	Creative	84	70.928	10.47667	1.14310

Based on the output tables, the mean NGain percent values for critical thinking (70.9252) and creative thinking (70.9284) fall within the category of "Quite Effective." This indicates that the developed book is reasonably effective in influencing both critical and creative thinking skills among students.

The term "Quite Effective" suggests a substantial positive impact on students' thinking abilities. The NGain results affirm that the book has contributed significantly to the improvement of critical and creative thinking skills in the students who participated in the study.

The final phase, evaluation, involved revising the teaching materials based on the feedback provided in the practicality questionnaire and teacher interviews. Suggestions from students included adding more images and contextual stories to the developed book. Teachers recommended incorporating mind maps into the lesson materials. The final book revision addressed these suggestions by including additional images, mind maps, and contextual stories.

Recognizing the significance of critical and creative thinking skills for students, and considering the research results indicating a significant impact of the developed book on these skills, the importance of this study becomes evident. The developed book implemented the RADEC model and metacognitive strategy stages in its instructional design, aiming to minimize factors contributing to students' low critical and creative thinking skills.

The study acknowledges that students' limited critical and creative thinking abilities may result from various factors, such as teacher-centered instruction that emphasizes information delivery rather than the development of thinking skills. Students may tend to memorize facts and formulas rather than understanding concepts, and the lack of training in critical and creative thinking skills is evident (Arif et al., 2020; Reynawati & Purnomo, 2018; Zubaidah, 2010). The developed book empowers teachers to facilitate more effective learning experiences.

Conclusion

The development of Science (IPAS) teaching materials using the RADEC Model grounded in Metacognitive Strategies has undergone validation by subject matter experts in Science at the Elementary School, language experts, and learning media specialists. Validation results affirm that the developed book is declared valid and suitable for implementation. Through statistical analysis of the book's trial results in teaching, involving 84 students as respondents, it is evident that the developed book has a proven significant impact and is sufficiently effective in supporting efforts to enhance the critical and creative thinking skills of fourth-grade elementary school students. This outcome is promising for educators seeking innovative teaching materials to foster higher-order thinking skills in their students.

Acknowledgments

The author extends gratitude to the teachers of Mojosoongo 03 Elementary School in Surakarta city, Joglo Elementary School in Surakarta city, Kestalan Elementary School in Surakarta city, and Sambirejo Elementary School in Surakarta city for providing the opportunity to conduct research in their respective institutions

Author Contributions

The author extends gratitude to the research and article writing supervisors, Prof. H. Udin Syaefudin Sa'Ud, Ph.D., and Prof. Dr. Paed. H. Wahyu Sopandi, M.A. Thanks also to the validators: Dr. Achmad Basari Eko Wahyudi, S.Pd., M.Pd.; Dr. Feri Faila Sulfa, S.Psi., S.Pd., M.Pd.; and Oka Irmade, S.Pd., M.Pd.

Funding

This research did not receive external funding

Conflicts of Interest

The author states there is no conflict of interest.

References

- Agustin, M., Pratama, Y. A., Sopandi, W., Rosidah, I., & Indonesia, U. P. (2021). Pengaruh Model Pembelajaran RADEC Terhadap Keterampilan Berpikir Tingkat Tinggi Mahasiswa PGSD. *Jurnal Cakrawala Pendas*, 7(1), 140-152. <https://doi.org/http://dx.doi.org/10.31949/jcp.v7i1.2672>
- Arif, D. S. F., Zaenuri, & Cahyono, A. N. (2020). Analisis Kemampuan Berpikir Kritis Matematis Pada Model Problem Based Learning (PBL) Berbantu Media Pembelajaran Interaktif dan Google Classroom. *Prosiding Seminar Nasional Pascasarjana UNNES*, 3(1), 323-328. <https://doi.org/https://proceeding.unnes.ac.id/snpasca/article/view/594/512>

- Aulia, N. (2023). Penerapan Model Project Based Learning untuk Meningkatkan Kemampuan Berpikir Kreatif Siswa di Sekolah Dasar. *Jurnal Riset Madrasah Ibtidaiyah*, 3(1), 1-7. <https://doi.org/https://doi.org/10.32665/jurmia.v3i1.338>
- Branch, R. M. (2009). *Instructional Design: The ADDIE Approach*. Springer. <https://doi.org/https://doi.org/10.1007/978-0-387-09506-6>
- Fardani, Z., & Surya, E. (2017). Meningkatkan kemampuan berpikir kritis dalam pembelajaran matematika untuk membangun karakter bangsa (Issue December). <https://www.researchgate.net/profile/Zuhur-Fardani/...-pembe>
- Fauzan, A. S., Sinaga, P., & Purwana, U. (2020). Implementasi Strategi Pembelajaran Writing To Learn Menggunakan Format Tulisan Metakognitif Untuk Meningkatkan Kemampuan Kognitif dan Keterampilan Komunikasi siswa SMA pada Materi Usaha dan Energi. *WaPFI (Wahana Pendidikan ...)*, 5(2), 41-48. <https://doi.org/https://doi.org/10.17509/wapfi.v5i2.27158>
- Handayani, H., Sopandi, W., Syaodih, E., Suhendra, I., & Hermita, N. (2019). RADEC: An Alternative Learning of Higher Order Thinking Skills (HOTs) Students of Elementary School on Water Cycle. *Journal of Physics: Conference Series*, 1351(1). <https://doi.org/10.1088/1742-6596/1351/1/012074>
- Haryanti, Y. D. (2017). Model Problem Based Learning Membangun Kemampuan Berpikir Kritis Siswa Sekolah Dasar. *Jurnal Cakrawala Pendas*, 3(2). <https://doi.org/10.31949/jcp.v3i2.596>
- Hasanuddin, Khairil, Samingan, Huda, I., & Agustina. (2020). Pengaruh Strategi Metakognitif terhadap Kemampuan Berpikir Kritis dan Hasil Belajar Peserta Didik pada Materi Sistem Pencernaan di SMAN Banda Aceh. *Jurnal Biotik*, 8(1), 60-76. <https://doi.org/10.22373/biotik.v8i1.6759>
- 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>
- Lampiran Permendikbud Nomor 21 Tahun 2016, (2016). https://repositori.kemdikbud.go.id/4791/2/Permendikbud_Tahun2016_Nomor021_Lampiran.pdf
- Irawan, B. P. (2020). Meningkatkan Kemampuan Berpikir Kreatif Dan Pemecahan Masalah Matematis Dengan Pembelajaran Metakognitif. *Jurnal Pendidikan Matematika: Judika Education*, 3(2), 75-84. <https://doi.org/https://doi.org/0.31539/judika.v3i2.1624>
- Jumanto, Sopandi, W., Kuncoro, Y., Handayani, H., & Suryana, N. (2018). The effect of radec model and expository model on creative thinking ability in. *ICEE 2018 International Conference on Elementary Education Universitas Pendidikan Indonesia*, 561-567. <https://doi.org/http://proceedings.upi.edu/index.php/icee/article/view/83/79>
- Kemendikbudristek. (2022). Dimensi, Elemen, dan Subelemen Profil Pelajar Pancasila pada Kurikulum Merdeka. In *Kemendikbudristek*. Badan Standar, Kurikulum, dan Asesmen Pendidikan, Kementerian Pendidikan, Kebudayaan, Riset, dan Teknologi Republik Indonesia.
- Permendikbud Nomor 22 Tahun 2020, Kementerian Pendidikan dan Kebudayaan 174 (2020). <https://peraturan.bpk.go.id/Home/Details/163750/permendikbud-no-22-tahun-2020>
- Khoiriah, T. (2015). Strategi pembelajaran metakognitif terhadap hasil belajar siswa pada konsep sistem pencernaan pada manusia. *Jurnal Pengajaran MIPA*, 20(2), 177-180. <https://doi.org/http://dx.doi.org/10.18269/jpmpa.v20i2.581>
- Liang, W., & Fung, D. (2020). Fostering Critical Thinking in English-as-a-Second-Language Classrooms: Challenges and Opportunities. *Thinking Skills and Creativity*, 39, 100769. <https://doi.org/10.1016/j.tsc.2020.100769>
- Lukmanudin. (2018). *Penguasaan Konsep IPA dan Kemampuan Menjelaskan Perpindahan Zat Pencemar Mahasiswa PGSD melalui Pembelajaran Read-Answer-Discuss-Explain-and Create*. https://repository.upi.edu/45337/1/T_PD_1607472_Title.pdf
- Ma'arif, A. S., Wahyu, W., & Sopandi, W. (2020). *Colloidal Learning Design using Radec Model with Stem Approach Based Google Classroom to Develop Student Creativity*. 4(4), 758-765. <https://doi.org/http://dx.doi.org/10.31258/jes.4.4.p.758-765>
- Manassero-Mas, M. A., Moreno-Salvo, A., & Vázquez-Alonso, Á. (2022). Development of an instrument to assess young people's attitudes toward critical thinking. *Thinking Skills and Creativity*, 45(September). <https://doi.org/https://doi.org/10.1016/j.tsc.2022.101100>
- Mardhiyah, R. H., Aldriani, S. N. F., & Chitta, F. (2021). Pentingnya Keterampilan Belajar di Abad 21 sebagai Tuntutan dalam Pengembangan Sumber Daya Manusia. *Lectura: Jurnal Pendidikan*, 29(40). <https://doi.org/10.31849/lectura.v12i1.5813>
- Musa'ad, F., & Suparman. (2023). Pengembangan E-Modul Berbasis Problem Based Learning untuk Memacu Kemampuan Berfikir Kritis Abad-21.

- AKSIOMA, 12(3), 3162-3171.
<https://doi.org/https://doi.org/10.24127/ajpm.v12i3.6119>
- O'Reilly, C., Devitt, A., & Hayes, N. (2022). Critical Thinking in the Preschool Classroom - A systematic literature review. *Thinking Skills and Creativity*, 46(agustus).
<https://doi.org/https://doi.org/10.1016/j.tsc.2022.101110>
- Ongardwanich, N., Kanjanawasee, S., & Tuipae, C. (2015). Development of 21 st Century Skill Scales as Perceived by Students. *Procedia - Social and Behavioral Sciences*, 191, 737-741.
<https://doi.org/10.1016/j.sbspro.2015.04.716>
- Piadi, R. (2017). Meningkatkan Kemampuan Komunikasi Matematis melalui Strategi Every One Is A Teacher Here dengan Pendekatan Metakognitif Siswa SMA. *Jurnal PJME*, 7(1), 31-44.
<https://doi.org/10.5035/pjme.v7i1.2701>
- Pratama, Y. A., Sopandi, W., Hidayah, Y., & Trihastuti, M. (2020). Pengaruh model pembelajaran RADEC terhadap keterampilan berpikir tingkat tinggi siswa sekolah dasar. *Jurnal Inovasi Pembelajaran*, 6(2), 191-203. <https://doi.org/10.22219/jinop.v1i1.2441>
- Rahman, A., Suherman, A., Susilawati, D., & Putra, G. P. (2020). RADEC (reading, answering, demonstrating, explaining, and creating) in lms to teach tennis without field practicing. *Universal Journal of Educational Research*, 8(11), 5433-5442.
<https://doi.org/10.13189/ujer.2020.081146>
- Rahmawati, H., Pujiastuti, P., & Cahyaningtyas, A. P. (2023). Kategorisasi Kemampuan Berpikir Kritis Siswa Kelas Empat Sekolah Dasar di SD se-Gugus II Kapanewon Playen , Gunung Kidul. *Jurnal Pendidikan Dan Kebudayaan*, 8(1), 88-104.
<https://doi.org/10.24832/jpnk.v8i1.3338>
- Redhana, I. W. (2019). Mengembangkan Keterampilan Abad ke-21 dalam Pembelajaran Kimia. *Jurnal Inovasi Pendidikan Kimia*, 13(1), 2239-2253.
<https://doi.org/https://doi.org/10.15294/jipk.v13i1.17824>
- Reynawati, A., & Purnomo, T. (2018). Penerapan Model Problem Based Learning pada Materi Pencemaran Lingkungan untuk Melatihkan Keterampilan Berpikir Kreatif Siswa. *PenSa: Pendidikan Sains*, 6(2), 325-329.
<https://ejournal.unesa.ac.id/index.php/pensa/article/download/24268/22193/>
- Sapitri, I., Surya, Y. F., Pebriana, P. H., Marta, R., & Kusuma, Y. Y. (2023). Penerapan Model Pembelajaran Read Answer Discuss Explain And Create (RADEC) untuk Meningkatkan Kemampuan Berpikir Kritis Siswa di Sekolah Dasar. *MODELING*, 10(4), 573-585.
<https://doi.org/https://doi.org/10.36835/modeling.v10i4.1968>
- Setiawan, D., Sopandi, W., & Hartati, T. (2019). Kemampuan menulis teks eksplanasi dan penguasaan konsep siswa sekolah dasar melalui implementasi model pembelajaran RADEC. *Premiere Educandum : Jurnal Pendidikan Dasar Dan Pembelajaran*, 9(2), 130.
<https://doi.org/10.25273/pe.v9i2.4922>
- Setiawan, D., Sopandi, W., & Hartati, T. (2020). The influence of read, answer, discuss, explain, and create (RADEC) learning model on the concept mastery of elementary school students on the water cycle topic. *Journal of Physics: Conference Series*, 1521(4). <https://doi.org/10.1088/1742-6596/1521/4/042113>
- Siregar, L. S., Wahyu, W., & Sopandi, W. (2020). Polymer learning design using Read, Answer, Discuss, Explain and Create (RADEC) model based on Google Classroom to develop student's mastery of concepts. *Journal of Physics: Conference Series*, 1469(1). <https://doi.org/10.1088/1742-6596/1469/1/012078>
- Soinbala, H., & Mulyatna, F. (2019). Penerapan Strategi Pembelajaran Metakognitif dalam Meningkatkan Pemahaman Konsep Matematika. *Jurnal Pendidikan Matematika*, 2(1), 46-56.
<https://doi.org/http://dx.doi.org/10.36277/defemat.v2i1.39>
- Sopandi, W. (2017). The quality improvement of learning processes and achievements through the read-answer-discuss-explain-and create learning model implementation. *Proceeding 8th Pedagogy International Seminar 2017: Enhancement of Pedagogy in Cultural Diversity Toward Excellence in Education*, 8(229), 132-139.
<https://www.researchgate.net/p...2F0aW9uIn19>
- Sopandi, W., & Handayani, H. (2019). The Impact of Workshop on Implementation of Read-Answer-Discuss-Explain-And-Creat (RADEC) Learning Model on Pedagogic Competency of Elementary School Teachers. *Advances in Social Science, Education and Humanities Research*, 178(ICoIE 2018), 7-11. <https://doi.org/10.2991/icoie-18.2019.3>
- Stephanou, G., & Mpiontini, M.-H. (2017). Metacognitive Knowledge and Metacognitive Regulation in Self-Regulatory Learning Style, and in Its Effects on Performance Expectation and Subsequent Performance across Diverse School Subjects. *Psychology*, 08(12), 1941-1975.
<https://doi.org/10.4236/psych.2017.812125>
- Sunanto, L., & Asyiah, N. (2018). Pengaruh Strategi Metakognitif Terhadap Kemandirian Belajar Mahasiswa Pendidikan Guru Sekolah Dasar. *Jurnal Profesi Keguruan*, 4(1), 42-45.
<https://doi.org/https://journal.unnes.ac.id/nju/index.php/jpk/article/download/14221/7785>
- Susanti, R. M., Rokayah, & Kusmawan. (2023).

- Penerapan Model Pembelajaran RADEC Berbasis Literasi Sains untuk Meningkatkan Kemampuan Berpikir Kritis Siswa pada Mata Pelajaran IPA Kelas V Sekolah Dasar. *Jurnal Ilmiah Pendidikan Dasar*, 08(2), 5491-5516. <https://doi.org/https://doi.org/10.23969/jp.v8i2.9910>
- Treffinger, D. J., & Isaksen, S. G. (2005). Creative Problem Solving: The history, development, and implications for gifted education and talent development. *Gifted Child Quarterly*, 49(4), 342-353. <https://doi.org/https://doi.org/10.1177/001698620504900407>
- Ulfa, F. K. (2020). Kemampuan Koneksi Matematis dan Berpikir Kritis Siswa dalam Pembelajaran Matematika melalui Model Brain-Based Learning. *Jurnal Pendidikan Matematika*, 6, 106-116. <https://doi.org/https://doi.org/10.33474/jpm.v6i2.5537>
- Virgia, Z., Granita, & Nelson, Z. (2019). Pengaruh Penerapan Strategi Metakognitif terhadap Kemampuan Pemahaman Konsep dan Pemecahan Masalah Matematis Siswa SMP. *Journal for Research in Mathematics Learning*, 2(4), 371-379. [http://download.garuda.kemdikbud.go.id/article.php?article=1486016&val=11336&title=Pengaruh Penerapan Strategi Metakognitif terhadap Kemampuan Pemahaman Konsep dan Pemecahan Masalah Matematis Siswa SMP](http://download.garuda.kemdikbud.go.id/article.php?article=1486016&val=11336&title=Pengaruh%20Penerapan%20Strategi%20Metakognitif%20terhadap%20Kemampuan%20Pemahaman%20Konsep%20dan%20Pemecahan%20Masalah%20Matematis%20Siswa%20SMP)
- Vitriasari, L., Sopandi, W., Sujana, A., Ainunasya, R. N., Nenden, K., & Wandani, R. W. (2023). Upaya Meningkatkan Keterampilan Berpikir Kritis pada Materi Teknologi Pangan melalui Model Pembelajaran RADEC di Kelas 3 SD. *Literasi*, 13(2), 777-786. <https://journal.unpas.ac.id/index.php/literasi/article/view/8257>
- Wanelly, W., & Fauzan, A. (2020). Pengaruh Pendekatan Open-Ended dan Gaya Belajar Siswa Terhadap Kemampuan Berpikir Kreatif Matematis. *JURNAL BASICEDU*, 4(3), 523-533. <https://doi.org/10.31004/basicedu.v4i3.388>
- Yasir, M. (2020). Analisis Atensi Calon Guru IPA melalui Strategi Metakognitif dalam Pembelajaran Ekologi. *Jurnal Inovasi Pembelajaran Biologi*, 1(1), 10-18. <https://doi.org/http://dx.doi.org/10.26740/jipb.v1n1.p10-18>
- Zubaidah, S. (2010). Berpikir Kritis: kemampuan berpikir tingkat tinggi yang dapat dikembangkan melalui pembelajaran sains. *Makalah Seminar Nasional Sains Pascasarjana Unesa*, Vol. 16.(January 2010). <https://www.researchgate.net/profile/Siti-Zubaidah-...2F0aW9uIn19>