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Prototype of Cartoon Concept Teaching Book Based on Contextual Approach to Train Students' Reflective Abstraction Skills

Helmi Rahmawati*, Saiful Fadli
Mathematic Education Department, Universitas Qamarul Huda Badaruddin Bagu, Indonesia.
*****Corresponding Author. Email: helmirahmawati18@gmail.com

Abstract: This research aims to produce a valid, practical, and effective cartoon concept teaching book based on a contextual approach for training students' reflective abstraction skills. This research method usesd research and development with the 4-D model, namely define, design, develop, and disseminate. Instruments used in this study include a validation sheet for the teaching book using the cartoon concept based on a contextual approach, a student response questionnaire, and pretest and posttest assessments of students' reflective abstraction skills. The descriptive-quantitative technique was used to analyze the research data. Data on product-developed validity and practicality were analyzed descriptively. In contrast, the product's effectiveness was analyzed descriptively using the n-gain formula and quantitatively using pretest-posttest control group design. The results of the study indicated that (1) the validity of the teaching book using the cartoon concept based on a contextual approach was valid (3.43) and reliable (85.71), (2) the practicality of the teaching book was considered practical with an average of 65.96, categorized as excellent, (3) statistical test results showed that the teaching book using the cartoon concept based on a contextual approach had a significant effect (sig. 2-tailed < 0.05) on students' reflective abstraction abilities. The average improvement in pretest and posttest reflective abstraction skills was indicated by the N-Gain value in the experimental group (0.58 - moderate) and the control group (0.25 - low). Students in the control class performed reflective abstraction up to the process stage, while students in the experimental class engaged in reflective abstraction up to the object stage. Thus, the teaching book using the cartoon concept based on a contextual approach is valid, practical, and effective in training students' reflective abstraction skills.

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Introduction

The use of mathematics extends beyond mere calculation (Kuswanti et al., 2017) and encompasses the organization of thought processes to solve encountered problems (Rahmawati et al., 2021). Mathematics is considered foundational for success in educational levels (Rahmawati et al., 2018) and higher-level careers (Li & Schoenfeld, 2019). Unfortunately, students generally perceive mathematics as a challenging subject (Fritz et al., 2019; Rahmawati, 2021). This issue is attributed to the lack of concept implantation in learning (Sari et al., 2019), aligning with the TIMSS study results indicating that Indonesian students fall into the low category (Prastyo, 2020). The study demonstrates that Indonesian students can solve basic problems but struggle with contexts requiring an understanding of advanced concepts.

Concepts are the fundamental building blocks for thinking and communication, forming the foundation of the idea network guiding students' thoughts (Rahmawati et al.,

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2018). However, current student understanding of concepts does not align with the curriculum's primary focus on mathematics learning (Fitri, 2017). Building students' understanding of mathematical concepts requires reflective abstraction skills, a knowledge construction from lower to higher levels through reflective processes on cognitive operations referencing mental structures (Rahmawati et al., 2018). The mechanism of reflective abstraction refers to the mental structure of the APOS theory aiming to construct new mental structures (Cahyani et al., 2019).

Reflective abstraction skills can be taught by learning a cartoon concept based on a contextual approach supported by appropriate teaching materials. In line with this statement, Jamal et al. (2019) states that it is essential to consider the effectiveness of concept cartoons in promoting discussion skills, learning fun, attitudes, interests, and student achievement. Concept cartoons engage students through visuals and words, increasing motivation and cognitive development, and fostering higher-order critical thinking skills (Demirci, 2017). Moreover, using concept cartoons in informal science learning stimulates curiosity and develops public understanding of science, regardless of professional interests (Atasoy et al., 2020). In the context of teaching methods, concept cartoons have been shown to decrease student misconceptions, increase interest in lessons, and effectively manage classrooms (Karahan & Caganaga, 2017). The cartoon concept is a useful tool for students' cognitive development, aiding in developing advanced critical thinking skills, prompting students to reflect on their thoughts or feelings, and creating an active environment for classroom discussions (Huang & Li, 2020). The contextual approach links the taught material with examples or problems from students' daily lives, making mathematics learning more relevant and easily understood by students themselves (Mardianto et al., 2022). Research findings conclude that using the cartoon concept in teaching 6th-grade students about prime numbers and division topics positively affects academic achievement (Kaplan & Öztürk, 2015).

Previous research on reflective abstraction using the APOS mental structure indicated that females perform better than male students with a fair category, recommending further research to improve these results (Rahmawati et al., 2018). Many studies have analyzed reflective abstraction levels from secondary school to higher education levels (Sutrisna et al., 2021, 2022; Widiyasari et al., 2020; Yusepa, 2017). Previous research focused solely on identifying and characterizing reflective abstraction skills rather than on teaching efforts using instructional materials to train reflective abstraction skills. Teaching reflective abstraction skills is recommended practically using appropriate learning models identified in previous research (Widiyasari et al., 2020). Based on the research gap described, this study aims to produce a teaching book using the cartoon concept based on a contextual approach that is valid, practical, and effective in training students' reflective abstraction skills, demonstrated through the mental components of internalization, encapsulation, and thematization (Rahmawati et al., 2018) based on the APOS theory in reconstructing the division concept (Cetin & Dubinsky, 2017).

Research Method

This development study began with preparing a teaching book for division using the cartoon concept based on a contextual approach, following the 4D model (Thiagarajan et al., 1974). The development process of the product, which is the teaching book using the cartoon concept based on a contextual approach, refers to the indicators of reflective abstraction in the form of actions, processes, objects, and schemes through the processes of internalization, encapsulation, and thematization (Rahmawati et al., 2018). Furthermore, the indicators, stages, and processes of students' reflective abstraction skills in this study were presented in

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Table 1, considering the criteria for the quality of the resulting teaching book, namely validity, practicality, and effectiveness (Nieveen & Folmer, 2013).

Table 1. Indicators of Students' Reflective Abstraction Skills (Rahmawati et al., 2018)

Reflective Abstraction			
Step	**Indicators**	**Description**	**Process**
Action	Connecting mathematical knowledge related to division material to find answers.	At this stage, students perform operations, but the operations conducted may be incorrect (misguided).	Internalization
Process	Connecting additional mathematical knowledge with division material to find the solution.	At this stage, students can perform operations correctly. They can explain the components of the answer but have not fully explained why the solution steps are taken.	
Object	Integrating mathematical knowledge with a comprehensive understanding of division concepts.	Students can perform operations correctly, comprehend the transformations, and articulate the rules employed at each solution step.	Encapsulation
Schema	Connecting actions, processes, and objects to form a division scheme.	Utilizing the scheme formed through actions, processes, and objects in the mind to construct new objects to solve more complex tasks.	Thematization

The resulting product was first validated before testing for the practicality and effectiveness of the teaching book using the cartoon concept based on a contextual approach in training students' reflective abstraction skills. The research data were analyzed descriptively and statistically.

Subject and procedure

The determination of the research area was conducted using the purposive sampling area method, meaning that the area is intentionally chosen based on specific considerations. This research was carried out at MI NW Tanak Beak in the academic year 2023/2024, the odd semester, with the research subjects being the fourth-grade class IV A, consisting of 24 students as the experimental group, and class IV B, consisting of 23 students as the control group. The development process consisted of four stages: define (definition), design (design), develop (development), and disseminate (dissemination). In the define stage, curriculum analysis, student analysis, task analysis, and concept analysis were conducted, followed by formulating learning objectives. In the design stage, the teaching book for division was prepared using the cartoon concept based on a contextual approach, and the research instruments were carried out. In the development stage, the teaching book was validated to determine its validity, followed by limited trials. In the dissemination stage, field tests were conducted to assess the practicality and effectiveness of the teaching book. The practicality of the teaching book was evaluated based on the analysis of student responses to learning using the teaching book. Meanwhile, the effectiveness of the teaching book was assessed based on improving students' reflective abstraction skills. The effectiveness of the product was tested using a quasi-experimental research design.

Product validity

The validity conducted encompassed content and construct validity elements on the components of the teaching book. Content validity implies that all components composing the developed teaching book should be based on needs and state-of-the-art. In contrast, construct validity means that all components should be consistently related. The developed teaching book was validated by two experts using the validation sheet based on a contextual approach for the teaching book on the cartoon concept. Both validators were senior lecturers

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with doctorate degrees with expertise in mathematics as product (content) and learning media. The teaching book's validity analysis was determined based on the average total score of the validation results, referring to validity criteria (Sabri et al., 2022) outlined in Table 2.

Table 2. Product validity criteria

Interval	Category	Description
1.0 ≤ Va ≤ 1.5	not valid	Cannot be used; needs consultation
1.6 ≤ Va ≤ 2.5	Less valid	It can be used with significant revision
2.6 ≤ Va ≤ 3.5	Valid	It can be used with minor revision
3.6 ≤ Va ≤ 4.0	Highly valid	It can be used with no revision

Product practicality

The practicality of the developed product was assessed based on students' responses to learning using the teaching book on the cartoon concept based on a contextual approach. Student responses are measured using a questionnaire. The data from the student response questionnaire, structured with an interval from 1 to 5, are then calculated for the average score using Equation 1. Whes, $\overline{X}$: mean score; X_i : total score of *i*, wheres $i = 1,2,3, \ldots, n$; n : number of participant.

$$\overline{X} = \frac{\sum_{i=0}^{n} X_i}{n} \quad \ldots\ldots (1)$$

The obtained scores were then converted into qualitative values according to the assessment criteria (Widoyoko & Qudsy, 2009) outlined in Table 3. Where, $\overline{X}_i$ (ideal mean): ½ (ideal maximum score + ideal minimum score); SB_i (ideal standard deviation): 1/6 (ideal maximum score – ideal minimum score); Ideal maximum score: ∑(assessment item × highest score); Ideal minimum score: ∑(assessment item × lowest score); $\overline{X}$: Average score.

Table 3. students response criteria

Score interval	Criteria
$X > (\overline{X}_i + 1.8SB_i)$	Very good
$(\overline{X}_i + 0.6SB_i) < X \leq (\overline{X}_i + 1.8SB_i)$	Good
$(\overline{X}_i - 0.6SB_i) < X \leq (\overline{X}_i + 0.6SB_i)$	Medium
$(\overline{X}_i - 1.8SB_i) < X \leq (\overline{X}_i - 0.6SB_i)$	Low
$X \leq (\overline{X}_i - 1.8SB_i)$	Very low

Product Effectiveness

The effectiveness of the developed teaching book was assessed by comparing posttest scores of students' reflective abstraction skills in the control and experimental groups. Students' reflective abstraction skills were measured using an essay-type test consisting of 5 items. The improvement in students' reflective abstraction skills in the experimental and control groups was analyzed descriptively using the n-gain equation (Hake, 1999) (Equation 2) and further categorized using the criteria outlined in Table 4.

$$N - Gain < g > = \frac{(posttest\ average) - (pretest\ average)}{100 - (pretest\ average)} \quad \ldots\ldots (2)$$

Table 4. Students' reflective abstraction skills improvement criteria

Interval	Criteria
$g \geq 0,7$	High
$0,3 < g < 0,7$	Moderate
$g < 0,3$	Low

The pretest-posttest control group design (Fraenkel et al., 2012) was employed during the product testing phase to evaluate the effectiveness of the developed product. The

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product's effectiveness was statistically tested using an independent samples t-test with the assistance of SPSS 16.0 for Windows software. The hypotheses used in this study are as follows.

$H_0: \mu_1 = \mu_2$
$H_1: \mu_1 > \mu_2$

With H0: There was no significant difference in reflective abstraction skills between the experimental and control groups; and Ha: Reflective abstraction skills in the experimental group were better than those in the control group. The conclusion was drawn at a 95% confidence level (5% significance) with the criterion that H0 was rejected if the sig value (2-tailed) ≤ 0.05. The teaching book was deemed effective in improving students' reflective abstraction skills if H0 was rejected, thereby accepting H1, indicating a difference in reflective abstraction skills between the experimental and control groups, or in other words, the reflective abstraction skills in the experimental group are higher than those in the control group.

Results and Discussion

Product validity

Based on the analysis of the validity scores of the teaching book on the cartoon concept based on a contextual approach validated by two mathematics education lecturers, it was known that the developed teaching book was declared valid (score: 3.43) and reliable (r: 0.85). The results of the validation of the teaching book are presented in Table 5.

Table 5. Results of Teaching Book Validation

No	Aspect assessed	Mean	Category	R (%)
1	Content	3.38	Valid	85.71
2	Language	3.54	Valid	
3	Presentation	3.36	Valid	
	Average	3.43	Valid	

Based on Table 4, it is evident that all aspects of the validation results for the Teaching Book have an average ranging between 3.36-3.54 (3.43), categorized as valid. Moreover, each aspect has a reliability of 85.71%, indicating that the developed teaching book was suitable for training students' reflective abstraction skills. Regarding content feasibility, the teaching book covered material on division, broadly discussing the definition and concept of division, division with 1-digit numbers, division with 2-digit numbers, and decimal division. The assessment from validators regarding the content aspect was good and aligns with the current curriculum requirements. The use of the cartoon concept featuring Upin and Ipin was well-received by most students. The problems presented were highly contextual, relating to students' everyday issues. Employing a contextual approach makes it easier for students to understand the division concept, where division material was closely related to daily life. Contextual teaching and learning (CTL) is an educational process that is holistic and aims to motivate students to understand the meaning of the material they are learning by connecting it through the context of their daily lives (personal, social, and cultural contexts) (Rahmadani et al., 2023). Thus, this teaching book is an appropriate learning resource for students to train reflective abstraction skills in understanding the division concept. To comprehend the concept of a subject, a proper and valid teaching book is required to guide students in understanding the material. According to Asy'ari et al. (2019), invalidly presented material renders a teaching book unable to function correctly as a learning resource. It does not serve as effective support for optimal learning quality.

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In terms of presentation, this teaching book explains problem-solving steps, stimulating reflective abstraction in forming the division concept. The book also includes exercises helpful in training students to solve division problems, allowing teachers to assess the extent of students' understanding of the division concept. To enable independent learning, students need a book presenting structured and systematic material, complete with examples and exercises, along with their explanations (Yolanda & Wahyuni, 2022). Regarding the language aspect used in this teaching book, the validator suggests simplifying sentences in explaining the material and revising it so that the developed teaching book can be readable by students, making the presented material easier to understand. Table 6 presents some suggestions provided by the validator.

Table 6. Suggestions and Improvements for the Teaching Book

Recommendation	Revision
Simplification of sentences in explaining the presented material is needed.	Sentences in explaining the material have been simplified.
The learning objectives from 1 to 8 need to be simplified for a more effective use of learning time.	Learning objectives have been simplified.
Usage instructions for the textbook need to be created for each meeting, both for teachers and students.	User instructions for the textbook have been created.

Table 6 presents several suggestions provided by the validator and the necessary improvements to be made. After the necessary improvements are implemented, the student textbook can be utilized in the learning activities to train students' reflective abstraction skills. Therefore, this student textbook is now ready for use in teaching, as it has met the two criteria for usability: validity and appropriateness. The sample page of the teaching book developed is presented in Figure 1.

Figure 1. Sample page of the teaching book developed

Product praticality

The practicality of the teaching book was assessed based on the responses of the participants obtained through a questionnaire method given to 24 students. The data obtained is presented in Table 7.

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Table 7. Students' response

n	Summary	Average	Criteria
24	1583	65,96	Very good

Based on the data in Table 6 above, the quantitative data on student responses yielded a total score of 1583 and an average of 65.96. This quantitative data was then converted into qualitative data to determine the practicality criteria of the teaching book. Based on these criteria, it can be concluded that the developed teaching book was considered practical as it meets the practicality standards through the average results, categorized as "very good." Practicality refers to the condition in which the developed teaching book was easy to use for users (simple, functions well, and not difficult to obtain and use).

Product effectiveness

The teaching book produced was tested for its effectiveness through learning using the teaching book, which has been declared valid and reliable for improving students' reflective abstraction skills. The normality of pretest and posttest data for reflective abstraction skills in the control and experimental groups was tested using SPSS 16.0 for Windows software, specifically the Kolmogorov-Smirnov normality test, as presented in Table 8.

Table 8. Normality of pretest and posttest data for students' reflective abstraction skills

Group	Test	N	Reflective abstraction			
			Mean	*Std. Deviation*	*Asymp. Sig. (2-tailed)*	Normality
Control	*pre-test*	23	34.83	9.893	.178	yes
	post-test	23	51.13	10.424	.096	yes
Experiment	*pre-test*	24	34.26	9.445	.108	yes
	post-test	24	72.33	15.311	.160	yes

Therefore, a paired samples test is used to analyze the impact of using the teaching book based on the contextual cartoon concept after learning about students' reflective abstraction skills. The achievements of students' reflective abstraction skills were presented in Table 9 and Table 10.

Table 9. Results of paired samples t-test for pre-test and post-test reflective abstraction skills in the control group

Score	Reflective abstraction mean score	N	SD	Sig. (2-tailed)
Pre-test	34.83	23	9.893	.000
Post-test	51.13		10.424	

Based on Table 9, a sig. 2-tailed value of < 0.05 was obtained, indicating that there is a significant change in the pretest and posttest results of reflective abstraction skills in the control group. Therefore, it can be concluded that conventional learning can train students' reflective abstraction skills in the division material.

Table 10. Results of paired samples t-test for pre-test and post-test reflective abstraction skills in the experimental group

Score	Reflective abstraction mean score	N	SD	Sig. (2-tailed)
Pre-test	34.26	24	9.445	.000
Post-test	72,33		15.311	

Table 10 showed the results of the paired samples t-test for the pre-test and post-test reflective abstraction skills of students in the experimental group, where it was found that sig. 2-tailed < 0.05, indicating a significant change in the pretest and posttest results. Therefore, it can be concluded that learning with the teaching book based on the contextual cartoon

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concept can train students' reflective abstraction skills in the division material. Next, to observe the difference in the average posttest scores between the control and experimental groups, an independent samples t-test was conducted using SPSS 16.0 for Windows software, as presented in Table 11.

Table 11. Results of independent samples t-test for posttest scores in the control group and the experimental group

	group	N	mean	SD	Sig. (2-tailed)
Posttest	Control	23	51.13	10.424	.000
	Experiment	24	72.33	15.311	

Based on Table 11, it is obtained that the sig. 2-tailed value is 0.000 < 0.05. Therefore, H0 is rejected, and H1 is accepted, meaning a significant difference exists between the posttest results of the control and experimental groups. Additionally, a difference in the average scores of the control group and the experimental group is observed. The average posttest score for the control group is 51.13, while the average posttest score for the experimental group is 72.33. Thus, a conclusion can be drawn that learning with the teaching book using the cartoon-based contextual approach is more effective than direct or conventional learning.

The effectiveness of the teaching book is further analyzed to determine the improvement in pretest and posttest results of reflective abstraction skills before and after using the teaching book with the cartoon-based contextual approach in the experimental group and the improvement in pretest and posttest results of reflective abstraction skills before and after conventional learning in the control group, using the N-Gain test. The average N-Gain results can be seen in Table 12.

Table 12. N-Gain test calculation results

Component	Experiment		Control	
	Pretest	**Posttest**	**Pretest**	**Posttest**
Highest score	54	91	53	75
Lowest score	20	40	20	36
Mean	34.26	72.33	34.83	51,13
N-Gain	**0.58**		**0.25**	
Category	**Medium**		**Low**	

Based on the N-Gain test results, the N-Gain value for the control group was 0.25, categorized as low. Meanwhile, the N-Gain value for the experimental group was 0.58, categorized as moderate. Thus, it can be concluded that the reflective abstraction skills of the experimental group were better than those of the control group. This implied that learning using the teaching book on division with a cartoon-based contextual approach was more effective in training students' reflective abstraction skills than conventional teaching methods.

The reflective abstraction skills test was used to assess the effectiveness of the teaching book with a cartoon-based contextual approach, consisting of five essay questions in the form of story problems for both the pretest and posttest. Student answers were analyzed by examining the solution steps taken by students based on reflective abstraction indicators. If a student only performs an operation and provides an incorrect answer, the student is considered to be at the action stage. Then, if a student answers correctly but does not write the meaning of the problem or the conclusion of what was asked in the problem, the student is considered to have interiorized the action into a process. Furthermore, suppose a student answers correctly and writes the meaning of the problem, including the conclusion asked in the problem. In that case, the student has reached the object stage, where the student can encapsulate the process into an object. When a student can solve more complex problems, the student is considered to have thematicized the object into a scheme. In this study, the most

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challenging problem was placed in question 5, which involved division with a significant digit. Based on the analysis of student answers, the researcher generally concludes that in the experimental group, most students were only able to perform reflective abstraction up to the object stage, where students could answer the questions and write the conclusions asked in the questions. However, none were able to answer question number five correctly. Meanwhile, students in the control group could perform reflective abstraction up to the process stage, where students did not write the meaning of the questions in the problems.

The lack of ability of elementary students in question five arises from the difficulty of solving a division problem with a significant digit. In line with the current research result, Gonda et al. (2022) point out that division leads to the need to solve simple problems, indicating that the complexity of division problems may pose challenges for elementary students. Furthermore, Purnomo et al. (2019) found that elementary students rely more on procedural knowledge than conceptual knowledge when solving fraction division problems, indicating a dominance of procedural knowledge in their problem-solving approach. In addition, Klang et al. (2020) suggest that students have similar misconceptions about solving fraction problems, which could also extend to division problems (Nanna & Pratiwi, 2020). Furthermore, Ishak et al. (2021) emphasize the importance of implementing various teaching strategies in mathematics, emphasize the importance of implementing various teaching strategies in mathematics, especially for problem-solving, considering the diverse learning abilities of students. It highlights the need for tailored instructional approaches to address students' challenges in division problem-solving. Moreover, the research conducted by Anjarsari et al. (2022) suggests that context-based teaching materials in thematic learning effectively improve elementary school students' critical thinking skills. The study's results by Ridwan et al. (2016) also indicate that developing context-based teaching materials for social arithmetic material can improve students' critical thinking skills in retrospect learning assisted by information and communication technology.

Using concept cartoons in a contextual approach can significantly impact elementary school students' reflective abstraction skills in the division subject matter. Concept cartoons have been shown to enhance reflective thinking skills, engagement, and academic achievement (Demirci, 2017).). Additionally, the contextual teaching and learning approach in mathematics education has been found to anchor teaching in students' diverse life contexts, preparing them for complex learning environments and future careers (Selvianiresa & Prabawanto, 2017). Furthermore, in line with this research result, concept cartoons have been associated with improved numeracy and science performance in kindergarten pupils, indicating their potential to enhance mathematical skills in young learners (Asare et al., 2022).

Moreover, applying contextual teaching and learning models has been linked to students' improved mathematical connection ability and reflective thinking skills (Ahmad et al., 2022). It suggests that integrating contextual approaches can positively impact students' reflective abstraction skills. Additionally, the effects of using concept cartoons have been shown to encourage critical thinking and create critical discussions among students, fostering an environment conducive to reflective thinking (Demirci, 2017). Therefore, integrating concept cartoons and contextual teaching and learning approaches can have conceptual and practical implications for enhancing elementary school students' reflective abstraction skills in the division subject matter, ultimately fostering critical thinking, engagement, and academic achievement.

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Conclusion

Based on the results and discussion, the teaching book using the cartoon-based contextual approach is valid, practical, and effective in training students' reflective abstraction skills. The validator's assessment of the teaching book using the cartoon-based contextual approach was 3.43 (valid) with a reliability percentage of 85.71 (reliable). The practicality of the teaching book was considered practical, with an average of 65.96 and a category of very good.

Statistical tests were conducted on the pretest-posttest values of the control group and the pretest-posttest values of the experimental group using paired samples t-tests. The results showed that sig. 2-tailed < 0.05, indicating a significant change in pretest and posttest results for both the control and experimental groups. Subsequently, a statistical test was also performed on the posttest values of the control group compared to the experimental group using an independent samples t-test. The results showed that the teaching book using the cartoon-based contextual approach significantly affected students' reflective abstraction abilities (sig. 2-tailed < 0.05).

Furthermore, the N-Gain test examined the average improvement in pretest and posttest reflective abstraction skills. The analysis results indicated that the N-Gain value for the experimental group was 0.58 (moderate), while the N-Gain value for the control group was 0.25 (low). Students in the control group performed reflective abstraction up to the process stage, while students in the experimental group performed reflective abstraction up to the object stage.

Recommendation

The findings of this research are limited to the topic of division, reflective abstraction skills, and students at MI NW Tanak Beak. Therefore, generating similar products for other topics with a larger sample size is essential to obtain more comprehensive data for practical improvements in classroom learning to enhance reflective abstraction skills. Future research could focus on refining and optimizing the developed teaching materials. It may involve iterative testing and modification to enhance their validity, practicality, and effectiveness, ensuring continuous improvement in instructional resources. Moreover, comparative studies could be conducted to evaluate the effectiveness of the cartoon concept teaching book against other instructional methods. It could involve comparing outcomes with traditional teaching approaches or other innovative methods to identify the most effective strategies for developing reflective abstraction skills.

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