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Analyzing Strategies Employed By 7th Grade Students in Correctly and Incorrectly Answering Multiple-Choice Questions on "Reproduction, Growth, and Development in Living Things"

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Abstract

The objective of this research is to ascertain the cognitive and metacognitive strategies employed by 7th-grade students who correctly answered four multiple-choice questions pertaining to the "Reproduction, Growth, and Development in Living Things" unit, contrasting with those who answered incorrectly. Employing a multiple holistic case study approach within qualitative research methodology, six students from a public secondary school in Kars, Tukey, participated in the study. These students engaged in solving the aforementioned questions using the think-aloud technique, followed by semi-structured interviews after each question. The entire process, including solving the questions and subsequent interviews, was captured on camera and transcribed for analysis. The transcribed data underwent qualitative analysis using computer-based tools. Results revealed that students who answered correctly employed cognitive strategies such as contextualizing the question, rephrasing it, mental visualization, strategic reading techniques, and increased reading pace, in contrast to those who answered incorrectly. Additionally, those who answered correctly utilized metacognitive strategies including identifying and marking clues, note-taking, option marking, summarization, and option elimination. Notably, students who answered correctly exhibited a broader array of strategies compared to their counterparts who answered incorrectly.

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Introduction

In Turkey, rapid social, scientific, technological, and economic advancements, particularly in recent years, have profoundly reshaped the lifestyles of individuals. The impact of scientific and technological progress on individuals' lives is particularly evident. Across

the globe, economic shifts, scientific breakthroughs, technological innovations, and globalization continue to exert significant influence on people's way of life. Considering these dynamics, it becomes evident that countries must prioritize the cultivation of science literacy among their citizens to ensure a robust future. Science courses play a pivotal role in fostering science literacy (MoNE, 2018). Through the teaching of science courses, the objective is to equip individuals with the necessary attitudes, skills, knowledge, understanding, and values essential for cultivating critical thinking, research-inquiry capabilities, problem-solving skills, and decision-making abilities. Individuals characterized as science literate are adept at effectively utilizing and accessing information, making informed decisions on science-related matters by weighing available options, generating new knowledge, and resolving challenges (Batı & Kaptan, 2013). Within the vision of the science curriculum in Turkey, problem-solving emerges as a fundamental component for nurturing proficient science literates (Diken, 2014). A problem is defined as a situation causing cognitive perplexity, lacking a singular solution, and amenable to resolution through the correct application of the individual's knowledge (Turnuklu & Yeşildere, 2005). Problems may manifest as physical or mental challenges, yet regardless of their nature, their resolution hinges on cognitive processes. Problem-solving constitutes the endeavor to surmount uncertainties and barriers encountered in both everyday life and academic pursuits (Gelbal, 1991). It stands as a crucial mental skill essential for preparing students for the demands of both life and academic advancement (Ozsoy, 2005). Problem-solving entails an individual's capacity to transcend prior experiences and learned rules to devise novel and effective solutions to challenges (Korkut, 2002). As a cornerstone of 21st-century skills, problem-solving has garnered extensive attention from researchers striving to enhance student achievement (Kılıc & Samancı, 2005). One critical factor influencing individuals' problem-solving processes is the utilization of problem-solving strategies (Diken, 2014). These strategies serve as mental tools employed by students to navigate cognitive operations in pursuit of problem resolution (Karacam, 2009). Notably, problem-solving strategies can serve both cognitive and metacognitive purposes (Diken, 2020). Karacam (2009) highlights the interconnection between cognitive and metacognitive strategies, emphasizing that strategies are categorized as either cognitive or metacognitive based on their intended usage (Flavell, 1976, 1979; Livingstone, 1997). According to Hacker (1998), a cognitive strategy denotes an action directed toward advancing knowledge in pursuit of a cognitive objective. Metacognitive strategy refers to the approach utilized to assess whether the cognitive strategy employed is suitable for its intended purpose, determining its efficacy. As outlined by Cakıroglu (2007), cognitive strategy pertains to the methods employed by individuals directly in the learning process, whereas metacognitive strategy involves overseeing and regulating cognitive objectives. In the context of this study, the cognitive-metacognitive strategies employed by students who correctly answered multiple-choice questions related to the "Reproduction, Growth, and Development in Living Things" unit were analyzed and compared with those of students who answered incorrectly. The findings of this investigation offer insights into the distinct strategies employed by students who successfully tackled various question types within this unit. It is anticipated that by elucidating these strategies, future studies can focus on imparting these effective problem-solving approaches to students who struggled with similar questions, thereby enhancing their likelihood of providing correct responses.

Material and Methods

Research Design

In this study, the cognitive-metacognitive strategies utilized by 7th-grade students in a public secondary school located in the city center of Kars, Tukey were examined. Specifically, the focus was on comparing the strategies employed by students who correctly answered multiple-choice questions pertaining to the unit "Reproduction, Growth, and Development in Living Things" with those of students who answered incorrectly. The research employed a multiple holistic component of the case study approach (Yıldırım & Simsek, 2021), a qualitative research methodology (Yin, 2003) wherein cases are systematically compared with one another.

Participants

Six 7th-grade students attending a public school in the center of Kars, Turkey, voluntarily participated in the study. Their inclusion was determined in consultation with their science teachers. To ensure confidentiality, the students were assigned abbreviated names such as "O1, O2, O3, O4..." while their real names and the name of their secondary school remained undisclosed. This approach was adopted to safeguard the privacy of the participants and maintain the integrity of the study.

Data Collection Tools

Multiple Choice Questions for "Reproduction, Growth and Development in Living Things" Unit

The primary data collection tool employed in the study consisted of four multiple-choice questions centered around the "Reproduction, Growth, and Development in Living Things" unit. These questions were specifically designed for 7th-grade students as part of their science curriculum. To ensure the accuracy and appropriateness of the questions, they were selected from the "High School Transition Examination (LGS) Preparation Book" based on input from the students' science teachers. Additionally, to verify the scientific accuracy of the questions, they were reviewed by a faculty member proficient in the field of biology education. Any necessary corrections suggested by the expert were duly incorporated into the questions to ensure their validity and reliability for the study. In the study, four multiple-choice questions corresponding to the four subtopics within the "Reproduction, Growth, and Development in Living Things" unit were utilized. Specifically, question 1 pertained to "Growth and Development in Plants," question 2 to "Growth and Development in Animals," question 3 to "Types of Reproduction in Plants," and question 4 to "Types of Reproduction in Animals." The students engaged in solving these questions using the think-aloud protocol, a method aimed at elucidating the relationship between students' problem-solving performances and the underlying cognitive processes (Van Someren, Barnard, & Sandberg, 1994). Prior to attempting the questions, the students were briefed on the think-aloud protocol, instructed to verbalize all their cognitive processes and actions while solving the questions. Subsequently, their problem-solving processes were recorded on camera. The observation records of the students' think-aloud protocols during the question-solving sessions facilitated the identification and differentiation of the cognitive and metacognitive strategies employed by the students.

Multiple Choice Questions for "Reproduction, Growth and Development in Living Things" Unit

In the study, a semi-structured interview form adapted from Diken (2014) was employed to elicit insights into the cognitive-metacognitive strategies utilized by students when solving multiple-choice questions concerning the unit "Reproduction, Growth, and Development in Living Things." This interview protocol comprised a series of open-ended questions designed to probe into the students' use of strategies during the question-solving process. Following the completion of each question, students were engaged in semi-structured interviews wherein they were prompted to articulate the purposes underlying their strategy employment. This approach served to corroborate the observational data, enabling the differentiation of the strategies employed by students into cognitive and metacognitive categories.

The semi-structured interview questions utilized in the research are outlined as follows.

- *You engaged in certain actions such as taking notes or eliminating options while solving the question. Could you elaborate on the reasons behind these actions?
- *What advantages do you perceive in employing strategies like note-taking or option elimination during the question-solving process?

Research Process

The study commenced with a review of cognitive-metacognitive strategies research both domestically and internationally. Based on this review, a comprehensive list of cognitive-metacognitive strategies was compiled. Subsequently, four multiple-choice questions related to the "Reproduction, Growth, and Development in Living Things" unit were selected from High School Transition Examination (LGS)

preparation books and endorsed by science teachers. Semi-structured interview questions, devised by Diken (2014), were employed to elucidate the strategies utilized by students in solving these questions. Students participated in the study voluntarily, with their selection based on this criterion and their 7th-grade science course grade averages obtained with consent from school administrators, science teachers, and parents. The selected students, participating voluntarily, were briefed on the research procedures before commencing. Prior to tackling the questions, they were instructed on the think-aloud protocol by the researcher. Throughout the question-solving process, students verbalized their thoughts aloud, which were recorded on camera to capture their cognitive processes. Following each question-solving session, semi-structured interviews were conducted with the students. Subsequently, the observation records of the think-aloud protocols and camera recordings of the interviews were transcribed onto a computer. These transcribed data were then analyzed using specialized qualitative research analysis software.

Data Analysis

In the study, to discern the cognitive-metacognitive strategies employed by students who answered questions correctly versus those who answered incorrectly, analysis was conducted on camera recordings capturing students' question-solving processes and written transcriptions of video-recorded semi-structured interviews held post-solution. Categories were established to segregate strategies utilized by students during question-solving into cognitive and metacognitive, drawing from data obtained through the think-aloud technique and semi-structured interviews probing into the purposes behind their strategy employment. This approach facilitated the systematic examination of students' cognitive and metacognitive processes, allowing for a comprehensive understanding of the strategies employed in differentiating correct and incorrect responses.

The data collected from the research underwent coding and analysis utilizing a computer program designed for qualitative research analysis. To ensure the accuracy and reliability of the coding process, an academic expert with prior experience in related subjects was consulted regarding the separation of cognitive and metacognitive strategies. Following coding, a second academic coder independently coded the data related to a student's question-solving process. An assessment of the consistency between the codings revealed an agreement rate of 89%. Instances of disagreement were discussed between the coders, and any inconsistent data were revisited and reconciled to reach a mutual decision.

Findings

Below are tables presenting findings on the cognitive-metacognitive strategies used by students who correctly answered multiple-choice questions on the unit "Reproduction, Growth and Development in Living Things," compared to those who answered incorrectly. Students are denoted as O1, O2, O3, O4, with correct answers labeled as "C" and incorrect answers as "W." The tables detail the strategies employed for each question, distinguishing between cognitive and metacognitive approaches. This presentation facilitates an analysis of the effectiveness of different strategies in achieving correct responses.

Table 1 showcases the cognitive strategies employed by students who correctly answered the first question, contrasting with those who answered incorrectly.

Table 1 illustrates that students O1, O2, and O3, who responded correctly to question 1, employed cognitive strategies such as reading from the root of the question, expressing it in their own words, self-questioning, relating given information to daily life, and comparing options with the question text. In contrast, students O4, O5, and O6, who answered incorrectly, did not utilize these strategies. Moreover, the table indicates that O1, O2, and O3 utilized a greater number and variety of cognitive strategies compared to O4, O5, and O6, suggesting a correlation between strategy utilization and response accuracy.

Table 2 displays the metacognitive strategies employed by students who correctly answered question 1, contrasting with those who answered incorrectly.

In Table 2, it is evident that students O1, O2, and O3, who responded correctly to question 1, utilized metacognitive strategies such as underlining

Table 1: Cognitive strategies used differently by correct respondents from incorrect respondents to the 1st question

STUDENTS	O1	O2	O3	O4	O5	O6
QUESTION 1						
ANSWER	C	C	C	W	W	W
COGNITIVE STRATEGIES						
Visualization	✓	✓	✓	✓		
Reading by tracking words with a pen				✓	✓	
Root of the question reading	✓	✓				
Expressing in one’s own words	✓	✓	✓			
Self questioning	✓	✓				
Connecting with everyday life	✓	✓	✓			
Reflecting on the question	✓	✓	✓	✓	✓	✓
Figure interpretation	✓	✓		✓	✓	
Figure review	✓	✓	✓	✓	✓	✓
Comparing options with the question wording	✓	✓	✓			

Table 2: Differential use of metacognitive strategies between correct and incorrect respondents to the 1st question

STUDENTS	O1	O2	O3	O4	O5	O6
QUESTION 1						
ANSWER	C	C	C	W	W	W
METACOGNITIVE STRATEGIES						
Re-reading				√	√	
Underlining clues	√	√	√			
Marking options	√	√	√			

clues and marking options, distinguishing them from students O4, O5, and O6, who answered incorrectly. Additionally, Table 2 highlights that O1, O2, and O3 employed a greater variety and number of metacognitive strategies compared to O4, O5, and O6, indicating a discrepancy in strategy usage between the correct and incorrect respondents.

Table 3. *Cognitive strategies used by those who responded correctly to the 2nd question differently from those who responded incorrectly*

Table 3 illustrates that students O1, O2, and O3, who responded correctly to question 2, employed cognitive strategies such as visualization, reading from the root of the question, underlining key words, expressing in their own words, taking notes, comparing figures in the question text with options, and comparing figures with explanations in the question text. In contrast, students O4, O5, and O6, who answered incorrectly, did not utilize these strategies. Moreover, the table indicates that O1, O2, and O3 employed a greater variety and number of cognitive strategies compared to O4, O5, and O6, suggesting a relationship between strategy utilization and response accuracy.

Delineates the metacognitive strategies employed by students who correctly answered question 2, contrasting with those who answered incorrectly.

Table 3: Displays the cognitive strategies employed by students who answered question 2 correctly, contrasting with those who answered incorrectly.

STUDENTS	O1	O2	O3	O4	O5	O6
QUESTION 2						
ANSWER	C	C	C	W	W	W
COGNITIVE STRATEGIES						
Visualization	√	√	√			
Reading by tracking words with a pen				√	√	
Root of the problem reading	√	√				
Expressing in one's own words	√	√	√			
Self questioning	√	√	√			
Connecting with everyday life	√	√	√			
Reflecting on the question	√	√	√	√	√	√
Figure interpretation	√	√		√	√	
REVIEW						
Figure review	√	√	√	√	√	√
COMPARISON						
Comparing the options with the wording of the question	√	√	√			
Comparing the format with the explanations in the question text	√	√	√			

Table 4: Metacognitive strategies used by those who correctly responded to the 2nd question differently from those who incorrectly responded to the 2nd question

STUDENTS	O1	O2	O3	O4	O5	O6
QUESTION 2						
ANSWER	C	C	C	W	W	W
METACOGNITIVE STRATEGIES						
Re-reading	√	√	√	√	√	
Note taking	√	√	√			
Taking notes on the figure	√	√	√			
Reviewing the figure again	√	√	√	√	√	√
Marking options	√	√	√			
Marking the figure	√	√	√			
Option elimination	√	√	√			

Upon analyzing Table 4, it is evident that students O1, O2, and O3, who correctly answered question 2, employed metacognitive strategies such as note-taking, making notes on the figure, marking options, marking the figure, and eliminating options. This differed from the approach of students O4, O5, and O6, who answered incorrectly. Additionally, the table indicates that O1, O2, and O3 utilized a greater variety and number of metacognitive strategies compared to O4, O5, and O6, highlighting a correlation between strategy usage and response accuracy.

Table 5 outlines the cognitive strategies employed by students who answered question 3 correctly, contrasting with those who answered incorrectly.

Table 5: Cognitive strategies used by those who responded correctly to the 3rd question differently from those who responded incorrectly

STUDENTS	O1	O2	O3	O4	O5	O6
QUESTION 3						
ANSWER	C	C	C	W	W	W
COGNITIVE STRATEGIES						
Root of the question reading	√	√				
Part-by-part Identification	√	√				
Note taking	√	√	√			
Expressing in one’s own words	√	√	√			
Reading by tracking words with a pen				√	√	
Reading by underlining words	√	√	√			
Figure review	√	√	√	√	√	√
Comparing the format with the explanations in the question text	√	√	√			
Comparing the options with the wording of the question	√	√	√			
Comparing the form with the explanations in the text of the question	√	√	√			

Upon analysis of Table 5, it is evident that students O1, O2, and O3, who answered question 3 correctly, employed a variety of cognitive strategies. These strategies included reading from the root of the question, defining piece by piece, taking notes, expressing in their own sentences, reading by underlining words, comparing explanations in the question text with options, comparing figures in the question text with options, and comparing figures with explanations in the question text. In contrast, students O4, O5, and O6, who answered incorrectly, did not utilize these cognitive strategies. Furthermore, Table 5 demonstrates that students O1, O2, and O3 employed a greater number and variety of cognitive strategies compared to students O4, O5, and O6, indicating a relationship between strategy utilization and response accuracy.

Table 6 presents the metacognitive strategies employed by students who answered question 3 correctly, contrasting with those who answered incorrectly.

Upon analyzing Table 6, it is evident that students O1, O2, and O3, who correctly answered question 3, employed various metacognitive strategies. These strategies included repeating important points, increasing reading speed, taking notes, asking questions to oneself, expressing in one’s own words, reading by underlining words, rechecking options, marking explanations in the question text, marking options, marking the figure, and eliminating options. In contrast, students O4, O5, and O6, who answered incorrectly, did not utilize these metacognitive strategies. Furthermore, Table 6 indicates that students O1, O2, and O3 employed a greater number and variety of metacognitive strategies compared to students O4, O5, and O6.

Table 7 illustrates the cognitive strategies employed by students who answered question 4 correctly, contrasting with those who answered incorrectly.

Upon examination of Table 7, it is observed that students O1, O2, and O3, who correctly answered question 4, employed a range of cognitive strategies. These strategies included associating given information with daily life, reading from the root of the question, taking notes, asking questions to themselves, expressing in their own words, reading by underlining words, increasing reading speed, comparing explanations in the question text with options, comparing the graph in the question text with options, and comparing explanations in the question text with the graph. In contrast, students

Table 6: Metacognitive strategies used by those who correctly responded to the 3rd question differently from those who incorrectly responded to the 3rd question

STUDENTS	O1	O2	O3	O4	O5	O6
QUESTION 3						
ANSWER	C	C	C	W	W	W
METACOGNITIVE STRATEGIES						
Re-reading	√			√	√	
Repeating key points	√	√	√			
Improving reading speed	√	√	√			
Note taking	√	√				
Self questioning	√	√				
Expressing in one's own words	√		√			
Reading by underlining words	√	√	√			
Returning	√			√	√	
Double-checking options	√	√	√			
Reviewing the figure again	√	√	√			
Marking explanations in the text of the question	√	√				
Marking options	√	√				
Marking the figure	√		√			
Option elimination	√	√	√			

Table 7: Cognitive strategies used by those who responded correctly to the 4th question differently from those who responded incorrectly

STUDENTS	O1	O2	O3	O4	O5	O6
QUESTION 4						
ANSWER	C	C	C	W	W	W
COGNITIVE STRATEGIES						
Visualization	√	√		√		
Connecting with everyday life	√	√	√			
Root of the question reading	√	√				
Note taking	√	√				
Self questioning	√	√	√			
Expressing in one's own words	√	√				
Reading by underlining words	√	√	√			
Reading by tracking words with a pen				√	√	
Figure review				√	√	
Repeating words				√	√	
Reflecting on the question	√	√	√	√	√	√
Improving reading speed	√	√	√	√	√	√
Comparing the format with the explanations in the question text	√	√	√			
Comparing the options with the graph in the question text	√	√	√			
Contrasting the explanations in the question text with the graph	√	√	√			

Table 8: Metacognitive strategies used by those who correctly responded to the 4th question differently from those who incorrectly responded to the 4th question

STUDENTS	O1	O2	O3	O4	O5	O6
QUESTION 4						
ANSWER	C	C	C	W	W	W
METACOGNITIVE STRATEGIES						
Re-reading	√	√		√	√	
Repeating key points	√	√				
Improving reading speed	√		√			
Self questioning	√	√				
Reading by underlining words	√		√			
Underlining clues	√	√	√			
Circling the clues	√	√	√			
Checking the correctness of the selected option	√	√	√			
Repeating clues	√	√	√			
Reviewing the figure again	√	√	√	√	√	√
Taking notes on the figure	√	√	√			
Marking explanations in the text of the question	√	√	√			
Marking options	√	√	√			

O4, O5, and O6, who answered incorrectly, did not utilize these cognitive strategies. Furthermore, Table 7 indicates that students O1, O2, and O3 employed a greater number and variety of cognitive strategies compared to students O4, O5, and O6.

Table 8 outlines the metacognitive strategies employed by students who correctly answered question 4, contrasting with those who answered incorrectly

Upon reviewing Table 8, it becomes evident that students O1, O2, and O3, who correctly answered the 4th question, employed a range of metacognitive strategies. These strategies encompassed repeating important points, increasing reading speed, asking questions to themselves, underlining words and clues, circling clues, checking option correctness, repeating clues, taking notes on the figure, and marking both explanations in the question text and options. Conversely, students O4, O5, and O6, who answered incorrectly, did not utilize these metacognitive strategies. Table 8 reveals that students O1, O2, and O3, who answered the 4th question correctly, employed a greater variety and quantity of metacognitive strategies compared to students O4, O5, and O6, who answered incorrectly.

Conclusion and Discussion

The findings of this research revealed distinct differences between seventh-grade students who correctly answered questions in the "Reproduction, Growth and Development in Living Things" unit and those who answered incorrectly. Specifically, students who answered correctly employed various cognitive strategies, including visualizing concepts, starting their reading from the root of the question, underlining keywords, expressing ideas in their own words, taking comprehensive notes, breaking down concepts into smaller parts, reading with increased speed, self-questioning, relating given information to everyday life, as well as comparing and contrasting figures, explanations, and graphs within the question text and provided options.

The study revealed that students who answered questions correctly employed a wide array of metacognitive strategies, including underlining and

circling clues, repeating and taking comprehensive notes, emphasizing important points, increasing reading speed, self-questioning, expressing ideas in their own words, and double-checking options. Furthermore, they utilized strategies such as marking explanations, options, and figures, as well as eliminating options and verifying the correctness of their chosen answers. Interestingly, students who answered all four questions correctly demonstrated a higher quantity and diversity of both cognitive and metacognitive strategies compared to those who answered incorrectly.

The cognitive-metacognitive strategies identified in this study are supported by previous literature. Robinson (1970), Thomas & Robinson (1972), Eanet & Manzo (1976), Charles, Lester & O'Daffer (1987), O'Malley & Chamot (1990), Montague (1992), Alderman et. al., (1993), Malloy (1994), Posamentier & Krulik (1998), Weir (1999), Goos, Galbraith, & Renshaw (2000), Karatas & Guven (2003), Taraban (2004), Victor (2004), Caliskan, Selçuk Sezgin, & Erol (2006), Anastasiou & Griva (2009), Caliskan, Selçuk Sezgin, & Erol (2006), Ghonsooly & Eghtesadee (2006), Selçuk Sezgin, Caliskan, & Erol (2007), Karacam (2009), Kumlu (2012), Diken (2014), Tutar (2016), Diken (2020a), Diken (2020b), Diken (2020c). In the literature, there are two notable studies examining the differences in strategies used by students who correctly versus incorrectly answered multiple-choice questions within the biology discipline of the science learning area. Diken & Yuruk (2019) investigated 9th grade students' approaches to biology questions and found that those who answered correctly employed cognitive strategies such as visualization, note-taking, expressing concepts in their own words, and breaking down information into smaller parts. Additionally, they utilized metacognitive strategies including reviewing, re-evaluating the process, re-reading, underlining keywords, circling important clues, self-questioning, reconsidering figures, underlining relevant clues, and increasing reading speed. In contrast, students who answered questions incorrectly demonstrated less use of these strategies. Tutar, Demir, & Diken (2020) discovered that 12th-grade students who answered multiple-choice biology questions correctly utilized cognitive strategies such as mental visualization, expressing concepts in their own words, and note-taking. Conversely, those who answered the questions incorrectly demonstrated less employment of these cognitive strategies but instead relied more on strategies like underlining or circling clues, marking options, rereading, eliminating options, underlining words, taking notes, marking figures, tables, or graphs in the question text, marking explanations in the question text, repeating important points, and reviewing figures, tables, or graphs in the question text.

The findings of this study suggest that teaching the strategies employed by successful students to those who answered questions incorrectly could enhance overall performance. Future research endeavors may focus on identifying effective strategies for correct responses across various units in science courses spanning 5th to 8th grade. By systematically integrating these strategies into educational practices, there is potential to improve students' ability to answer multiple-choice questions accurately across different grade levels and subject areas. By imparting the identified strategies to students who initially answer questions incorrectly, their likelihood of providing correct responses can be enhanced. Consequently, significant strides can be made in improving students' overall success in answering questions accurately across various question types.

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