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THE COMPARISION BETWEEN THE COGNITIVE AND METACOGNITIVE STRATEGIES USED BY 8TH GRADE STUDENTS TO SOLVE MULTIPLE-CHOICE QUESTIONS ON "PHOTOSYNTHESIS AND RESPIRATION"

Emine Hatun Diken[i]
Kafkas University,
Turkey

Abstract:
The primary aim of this paper is to identify the cognitive and metacognitive strategies used by 8th grade students for solving multiple-choice questions on "Photosynthesis and Respiration" which is among the main subjects of Biology and to compare these strategies according to the type of the school (public school- private school), the level overall grade point averages and the status of answering questions correctly or incorrectly. The study was designed as a qualitative case study. The participants of the study included 8 eighth-grade students in total, who were studying in a private, and in a public school located in the province of Kars. The students who participated in the study were asked to answer the multiple-choice questions on "Photosynthesis and Respiration" during thinking-aloud sessions. To identify whether the strategies used by students in the problem-solving process were cognitive or metacognitive, semi-structured interviews focused on students' purposes to use cognitive and metacognitive strategies were conducted with students directly after they solve each multiple-choice question. The data collected from the observation records of the processes of multiple-choice question solving, and semi-structured interviews were analysed. The studied data were analysed. The results of the study revealed that 8th grade students who were studying in a private school, whose overall grade point averages was at "Very Good" level, and who answered the multiple-choice questions correctly used a number of cognitive and metacognitive strategies while solving these questions. On the other hand, the students who were studying in a public school, whose overall grade point averages was at "Average" and "Poor" levels , and who answered the questions incorrectly, used a limited range of cognitive and metacognitive strategies.

Keywords: cognitive and metacognitive strategies, multiple-choice questions, photosynthesis and respiration

[i] Correspondence: email hatundiken06@gmail.com

1. Introduction

One of the main objectives of formal education in Turkey is teaching the necessary skills to students that will enable them to find effective solutions to problems they may face in their lives. Problem-solving skills are among the key set of skills for students. Science and mathematics courses have an essential role in improving students' problem-solving skills (Baki, Karatas, & Guven, 2002). Different approaches are adopted in science teaching to improve students' problem-solving skills. In Turkey, questions that require problem-solving skills of students are asked in central exams in a multiple-choice format. Based on the number of correct answers they have, students are placed in a higher level of educational institutions (high school or university). Therefore, the question of "What are the factors that help students to answer questions correctly?" is required to be answered in the context of science education (Karacam, 2009).

2. Literature Review

A considerable amount of literature has been published on problem-solving (Adelson 1984; Anderson, Greeno, Kline, & Neves, 1981; Chi, Feltovich, & Glaser, 1981; Clement, 1991; Dhillon, 1998; Diken, 2014, Diken & Yuruk, 2019; Finegold & Mass, 1985; Hegarty, Mayer, & Monk, 1995; Malone, 2006; Karacam, 2009; Mc Dermott & Larkin, 1978; Priest & Linsay, 1992; Reif & Allen, 1992; Savelsbergh, de Jong, & Ferguson-Hessler, 1986; Simon & Simon, 1978; Singh, 2002; Tuminaro & Redish, 2007; Tutar, Demir, & Diken, 2020). These studies were mostly focused on identifying the behaviours of students performed in the process of reaching the correct answer while solving questions. Gick (1986) and Savelsbergh, de Jong, & Ferguson-Hessler (1996) laid emphasis on the fact that students who answered questions correctly used a wide number of different strategies while solving the problem, on the other hand, students who answered questions incorrectly used a small range of strategies. The given situation is linked to the question of "How effective are the strategies that are used by students to solve a problem, for finding the right answer?" Briefly, the use of strategies has been highlighted as an important factor in the development of the problem-solving processes of students. These processes are associated with cognitive and metacognitive factors (Mayer, 2003). While solving questions, students use different components such as information related to the task, their existed knowledge about the field, strategies, and observations on the problem-solving process (Van Gog et al., 2005). Problem-solving is a complex process, and in light of the notion that metacognition has a significant role in problem-solving, some researchers addressed the problem-solving processes of students from a metacognitive perspective (Brown & Palincsar, 1982; Davidson, Deuser, & Sternberg, 1994; Campione et al., 1988; Garofalo & Lester, 1985; Gunstone & Mitchell, 1998; Goos, 2002; Lesh & Akerstrom, 1982; Schoenfeld, 1987; Silver, 1982; Schoenfeld, 1992; Wilson & Clark, 2002; Wilson, Fernandez, & Hadaway, 1993). Therefore, researchers who have been working on problem-solving proposed various emphasises and definitions

regarding metacognition. The researchers (Brown & Palincsar, 1982; Garofalo & Lester, 1985; Schoenfeld, 1987) defined metacognition as "*a type of reflection, a way of thinking about one's thinking, a whole organisation of cognition in light of the knowledge on cognition, and selection, planning and monitoring of what is needed to be done*".

One of the main components of metacognition is the metacognitive experiences of students. According to Flavell (1979), such experiences require a great deal of attention and induce a high level of conscious thinking and activate cognitive and metacognitive strategies. The strategies that students use to verify the accuracy of the processes while solving a question, or check whether they overlook a point are defined as "*metacognitive strategies*", and the strategies that students use to operate mental processes within a problem are called "*cognitive strategies*" (Diken, 2014; Karacam, 2009). According to Flavell (1976; 1979) and Livingstone (1997), cognitive and metacognitive strategies have a grifting structure. Therefore, a strategy could be defined as cognitive or metacognitive based on its purpose of use. In other words, the key and most important indicator to determine whether a strategy is cognitive or metacognitive is the purpose of using that particular strategy.

For example, the study of Diken (2014) described a student's behaviour to take notes to use while solving a multiple-choice question, and to avoid making a mistake as a cognitive strategy; and describe a student's behaviour to take notes about the hints on the question to be assured that there are no overlooked points as a metacognitive strategy. The aforementioned strategy used by students both for cognitive and metacognitive purposes while solving a problem was defined as "note-taking". The study of Diken and Yuruk (2019) suggested that in the context of the cognitive and metacognitive strategies used by students to solve multiple-choice questions, the strategies that might be useful to find the right answer of a question could be introduced to secondary school students, and to prospective teachers. In view of the above-mentioned research studies in the literature, this study aimed to identify cognitive and metacognitive strategies used by students to solve multiple-choice questions on "Photosynthesis and Respiration" which is among the major subjects of Biology discipline. Furthermore, these strategies were compared according to the type of schools that students were registered at (i.e. private school, public school), the level of level of overall academic achievement, and the status of answering the questions correctly. This study is expected to inspire researchers about further research on identifying which cognitive and metacognitive strategies should be taught to students for enabling them to find the right answers to multiple-choice questions in the discipline of biology.

3. Material and Methods

3.1 Pattern of the Study

This study aimed to identify the cognitive and metacognitive strategies used by 8th grade students -who were studying in a private or a public school and had different levels of overall grade point averages- for solving multiple-choice questions on the subject of

"Photosynthesis and Respiration". Furthermore, these cognitive and metacognitive strategies used by students to solve multiple-choice questions according to the type of the school (public school- private school), the level overall grade point averages, and the status of answering questions correctly or incorrectly. For the selection of the multiple-choice questions on the subject of "Photosynthesis and Respiration", opinions of a science teacher and a faculty member who had expertise in biology learning were taken. The qualitative study focused on few students who were studying in a private school and a public school, and the study was designed as a "case study". The study was formed as a multiple holistic case study (Yin, 2003) since each situation was addressed in itself holistically, and also compared with each other (Yıldırım & Simsek, 2018). The study focused on 8 students in total, including 4 students who were studying in a private school, and 4 students who were studying in a public school. In the scope of the study, qualitative data on the cognitive and metacognitive strategies used by students for solving multiple-choice questions on the subject of "Photosynthesis and Respiration", and the relationship between these strategies and types of schools that students were studying in (private or public school), the levels of overall grade point averages, and the status of answering the questions correctly or incorrectly. Afterwards, patterns between these cases were established.

3.2 Participants

The participants of the study included 8 eighth-grade students in total, including 4 students who were studying in a private school, and 4 students who were studying in a public school located in the province of Kars; who had different levels of overall grade point averages. These students were selected based on the "*maximum variation sampling"* suggested by Patton (2002). In the selection of these students who were studying in a private or public school, students' performances in the science course, and opinions of a science teacher were taken into consideration. Thus, the study emphasized the importance of selecting enriched data providers in the context of using cognitive and metacognitive strategies by students for solving multiple-choice questions on the subject of "Photosynthesis and Respiration", and different levels of overall grade point averages of students. The participants were selected on a voluntary basis. During the research study, the participants remained anonymous, and they were given nicknames as "S1, S2, S3, S4, S5, S6, S7, S8". The names of the private and public schools that students were registered were not revealed.

Table 1 shows the types of schools (private school-public school) that students who were participating in the study were registered at, the overall grade point averages, and the levels that correspond to these scores.

Table 1: Types of Schools, the Average Academic Achievement Scores of Students and Corresponding Levels

Type of High School	Nicknames of the Students	Overall Grade Point Averages	Level of Overall Grade Point Averages
Private Schools	S1	98	Very Good
	S2	94	Very Good
	S3	91	Very Good
	S4	84	Good
Public School	S5	85	Good
	S6	66	Average
	S7	52	Poor
	S8	50	Poor

Table 1 shows that the overall grade point averages of the students S1, S2, and S3 who were studying in a private school were 98, 94, 91, respectively; and the overall academic achievement scores of the students was at "Very Good" level. The overall grade point average of S4, who was studying in a private school, was 84, and the overall academic achievement was at "Good" level. The overall grade point average of S5 who was studying in a public school was 85, and the overall academic achievement score of the student was at "Very Good" level. The overall grade point average of S6 who was studying in a public school was 66, and the overall academic achievement score of the student was at "Fair" level. The overall grade point averages of S7 and S8 who were studying in a public school were 52 and 50 respectively, and the level of overall academic achievement of the students was at "Poor" level. The level of overall grade point averages of the students was determined according to the Regulation on Secondary Education Institutions released by the Ministry of Education (MEB, 2019). The regulation defines the overall grade point averages of the students that range between "85-100" as "Very Good", between "70-84" defined as "Good", between 60-69 as "Fair", between 50-59 as "Poor", and between 0-49" as "Very Poor" (MEB, 2019).

3.3 Data Collection Instruments

This study employed multiple data collection instruments in order to conduct a reliable, consistent, and profound analysis. The data collection instruments employed by the study are explained in detail below.

3.4 Thinking-Aloud Sessions Carried Out by Multiple-Choice Questions on the Subject of "Photosynthesis and Respiration"

The first data collection instrument that was used while students were solving multiple-choice questions on "Photosynthesis and Respiration" was the 'thinking aloud sessions'. In this process, the students were asked to solve two multiple-choice questions on "Photosynthesis and Respiration" which is a major subject of the 8th grade Biology discipline of life sciences. The questions were selected from the book titled "High School Preparation Book" in line with the opinions of the science teacher. The two questions that

were selected were used in the study since they had a potential to enable students to use a higher number of different strategies.

The multiple-choice questions selected for the study were related to the "Photosynthesis and Respiration" subject included in the unit titled "Transformation of Energy and Environmental Sciences", which was a part of the science curriculum of MEB (2018). The unit was selected due to the significant number of learning outcomes. Indeed, the High School Entrance Exam included several questions related to the above-mentioned unit and subject which offered a high number of learning outcomes. The multiple-choice questions on "Photosynthesis and Respiration" subject were checked by a faculty member who had expertise on biology learning field, and the final adjustments of the multiple-choice questions were made according to the feedback provided by the faculty member.

Table 2 shows the field of learning, subject area, unit, subject title, and the number of the learning outcomes of the unit, in the context of two multiple-choice questions that were asked to the students.

Table 2: The Field of Learning, Subject Area, Unit, Subject Title, and Number of Learning Outcomes of the Unit Related to the Multiple-Choice Questions

Questions	Field of Learning	Subject Area	Unit	Number of Learning Outcomes of the Unit	Subject Title
1st Question	Biology	Living Things and Life	Transformation of Energy and Environmental Sciences	12	Photosynthesis
2nd Question	Biology	Living Things and Life	Transformation of Energy and Environmental Sciences	12	Respiration

Table 2 shows that the multiple-choice questions asked to the 8th grade students were related to the subject "Photosynthesis and Respiration" which is a major topic of the Biology discipline of life sciences. The questions were also related to the subject area "Living Things and Life", to the unit "Transformation of Energy and Environmental Sciences", and to the subject "Photosynthesis and Respiration". The first multiple-choice question was related to the subject "Photosynthesis", and the second question was related to "Respiration".

The students were asked to solve two multiple-choice questions during the thinking-aloud sessions. Thinking aloud is a protocol that determines the relationship between problem-solving performances of students and the situations that affect the problem-solving process (Van Someren, Barnard, & Sandberg, 1994). Students were provided with necessary information about the thinking-aloud session before they were asked to solve the multiple-choice questions. In other words, the students were asked to express their processes of solving multiple-choice questions aloud. The process was recorded by a camera while students were solving multiple-choice questions. While the

students were solving the questions, the focus and direction of the camera were adjusted and controlled by the researcher when needed. Students were warned when they remained silent for a long time while solving the questions by saying "Can you please think aloud". The observations made during the thinking-aloud sessions conducted for monitoring students' processes of solving the multiple-choice questions provided an opportunity for identifying the strategies used by the students and distinguish these strategies as cognitive and metacognitive.

3.4 Semi-Structured Interview Form

Semi-structured interviews were conducted with 8th grade students who were studying in a private, and in a public school located in Kars province, for identifying the cognitive and metacognitive strategies that were activated in students' minds while solving the two predetermined multiple-choice questions on "Photosynthesis and Respiration", and the number and types of these strategies. The interviews were conducted with each student only once after a student solved a multiple-choice question.

In the study, a semi-structured interview form developed by Diken (2014) was used to identify the cognitive and metacognitive strategies used by students while solving multiple-choice questions. The students were asked questions after solving each question, related to their purposes of using their strategies to solve the questions to identify whether these strategies used by students to solve the two multiple-choice questions were cognitive or meta-cognitive. The semi-structured interview process was recorded in a video format.

The examples of the questions that were asked to the students to identify their purposes of using cognitive and metacognitive strategies to solve multiple-choice questions included:

- What did you do to solve the question? Can you explain this process step by step?
- Did anything occur in your mind while solving this question? If yes, what occurred in your mind?
- While solving the question you followed different ways? (eliminating options, marking the shape, etc.). Why did you do choose these ways?
- What kind of benefits such ways provided to you while solving the question (selecting an option, marking the shape, etc.)?
- Are you sure that the answer is correct?
- What is your reason for making sure that the answer is correct?

3.5 Research Process

The research process was discussed in three phases: "the phase before solving the multiple-choice questions", "the phase of solving the multiple-choice questions", and the "the phase after solving the multiple-choice questions".

3.5.1 The phase before solving the multiple-choice questions

In the study, the research studies that were conducted in different countries and Turkey were reviewed as the first step. Based on the reviewed literature, a list of cognitive and metacognitive strategies was prepared. The multiple-choice questions related to the subject "Photosynthesis and Respiration" were selected after an examination of the questions included in the preparation books for the "High School Entrance Exam (LGS)". Semi-structured interview questions formed by Diken (2014) were used to identify the cognitive and metacognitive strategies used by the students to solve the multiple-choice questions. The students were selected on a voluntary basis, and the overall grade point average scores of the students were received with the consent of students and parents. The students were informed about the implementation process of the research. The 8th grade students, who participated in the study, were also informed about the thinking-aloud sessions before they were asked to solve the multiple-choice questions.

3.5.2 The phase of solving the multiple-choice questions

The students were asked to think aloud in the problem-solving process to identify the cognitive and metacognitive strategies they used in the processes of solving the multiple-choice questions on "Photosynthesis and Respiration". This process was recorded by a camera. While the students were solving the questions, the focus and direction of the camera were adjusted and controlled by the researcher when needed.

3.5.3 The phase after solving the multiple-choice questions

After students solved the two multiple-choice questions, the researcher controlled whether there were any incomplete points in students' processes of solving the questions. The observations related to the thinking aloud sessions, processes of solving the multiple-choice questions, and the semi-structured interviews conducted with students for each question were decoded. Afterwards, the observations related to the thinking-aloud sessions regarding the students' processes of solving the multiple-choice questions, and the semi-structured interviews conducted with students for each question that were decoded, were analysed.

3.6 Data Analysis

The study aimed to identify the cognitive and metacognitive strategies used by 8th grade students for solving two multiple-choice questions on "Photosynthesis and Respiration" which is among the main subjects of Biology and to compare these strategies according to the type of the school (public school- private school), the level of overall grade point averages and the status of answering questions correctly or incorrectly. In the study, the observation records on students' processes of solving the questions, and the data collected from the semi-structured interviews were transferred to the computer environment and analysed to identify the cognitive and metacognitive strategies used by the students. To identify whether the strategies used by students were cognitive or

metacognitive, categories related to the observation records of the thinking-aloud sessions, and data sections related to the purposes of using the strategies were specified. The transcripts were coded by a software program that is commonly used for the analysis of qualitative research. To prove the accuracy of the data obtained as a result of coding an experienced faculty member was invited for a discussion during the data coding process, to verify the reliability and consistency of the data related to the type of the strategies which were defined as cognitive or metacognitive.

After the coding of the data, a data set consisted of a students' solutions of the multiple-choice were also coded by the faculty member, who was assigned as a coder. As a result of the coding, the consistency between the codes was found as %93. The coders worked on the inconsistent data sets one more time. The researcher and the experienced faculty member worked on the inconsistent data sections and reached a consensus.

4. Results and Discussion

In this section, the two multiple-choice questions on "Photosynthesis and Respiration" were examined and compared in view of 8th grade students' use of cognitive and metacognitive strategies, the type of the school (public school- private school), the level of overall grade point averages and the status of answering questions correctly or incorrectly.

Table 3 presents the cognitive strategies used by 8th grade students who were studying in a private and a public school, had different levels of overall grade point averages, and who answered the 1st question on "Photosynthesis" correctly or an incorrectly.

Table 3: The Cognitive Strategies Used by the Students with Different Levels Overall Grade Point Averages and Answered the 1st Question on "Photosynthesis" Correctly or Incorrectly

1st Question								
Schools	**Private School**				**Public School**			
Students	S1	S2	S3	S4	S5	S6	S7	S8
Answers	C	C	C	C	C	IC	IC	IC
Level of Overall Grade Point Average	VG	VG	VG	G	G	F	P	P
Cognitive Strategies								
Visualizing	√	√	√	√	√			
Reading While Tracking Words with a Pencil					√	√		
Starting to Read the Question from the Root	√	√	√	√				
Underlining the Words While Reading	√	√	√	√	√			
Rephrasing Questions with Own Words	√	√	√					
Note-Taking	√	√	√					
Examination								
Examining the Shapes	√	√	√	√	√	√	√	√
Comparison								
Comparing the Options with the Explanations Given in the Text of the Question	√	√	√					

Comparing the Options with the Shapes Given in the Text of the Question	√	√	√	√	√			
Comparing the Explanations Given in the Text of the Question with the Shapes	√	√	√	√	√			

Table 3 shows that S1, S2 and S3 who were studying in a private school, gave a correct answer to the first question on "Photosynthesis", and whose overall grade point averages were at the "Very Good" level used the cognitive skills including visualizing, starting to read the question from the root, underlining the words while reading, comparing the options with the explanations given in the text of the question, and comparing the options with the shapes given in the text of the question. According to the findings, S4 who was studying in a private school whose overall grade point average was at the "Good" level, and S5 who was studying in a public school whose overall grade point average was at the "Good" level used the cognitive strategies including visualizing, starting to read the question from the root, underlining the words while reading, examining the shapes and comparing the options with the shapes given in the text of the question. The findings indicated that S6, who was studying in a public school, gave an incorrect answer to the question, and whose overall grade point average was at the "Fair" level used the strategies including reading while tracking words with a pencil and examining the shapes. Lastly, S7 and S8 who were studying in a public school and whose overall grade point averages were at the "Poor" level used the cognitive strategy described as examining the shapes.

Table 3 shows that S1, S2 and S3 who gave a correct answer to the first multiple-choice and whose overall grade point averages were at the "Very Good" level, S4 whose overall grade point average was at the "Good" level, and S5 who was studying in a public school and whose overall grade point average was at the "Good" level used different strategies compared to S6, S7 and S8 who gave an incorrect answer to the multiple-choice question and whose overall grade point averages were at the "Fair" and the "Poor"; the strategies used by the first group of students included visualizing , starting to read the question from the root, underlining the words while reading, rephrasing questions with own words, note-taking, and comparing the options with the explanations given in the text of the question, and comparing the explanations given in the text of the question with the shapes.

Table 3 reveals that that S1, S2 and S3 who were studying in a private school, whose overall grade point averages were at the "Very Good" level, and who answered the first multiple-choice question correctly, used more cognitive strategies in terms of number and diversity compared to S4 and S5 who were studying in a private school and a public school, whose overall grade point averages were at the "Good" level, and who gave an correct answer to the question.

Table 3 also shows that S1, S2 S3, S4 and S5 who were studying in private and public schools and whose overall grade point averages were at the "Very Good" and "Good" levels, and who answered question correctly used more and different types of cognitive strategies compared to S6, S7 and S8 who were studying in a public school,

whose overall grade point averages were the "Fair" and "Poor" levels, and who answered the first question incorrectly.

Table 4 presents the metacognitive strategies used by 8th grade students who were studying in a private and public school, and had different levels of overall grade point averages and who answered the 1st question on "Photosynthesis" correctly or incorrectly.

Table 4: The Metacognitive Strategies Used by the Students with Different Levels Overall Grade Point Averages and Answered the 1st Question on "Photosynthesis" Correctly or Incorrectly

1st Question								
Schools	**Private School**				**Public School**			
Students	S1	S2	S3	S4	S5	S6	S7	S8
Answer	C	C	C	C	C	IC	IC	IC
Level of Overall Grade Point Average	VG	VG	VG	G	G	F	P	P
Metacognitive Strategies								
Rereading	√	√	√	√	√			
Reading while tracking words with a pencil	√	√	√					
Re-checking the Options	√	√	√					
Re-Examining								
Re-examining the shape	√	√	√	√	√	√	√	√
Marking								
Marking the Explanations in the Text of the Question	√	√	√	√	√			
Marking the Options	√	√	√	√	√			
Marking the Shapes	√	√	√	√	√			
Eliminating the Options	√	√	√	√	√			

Table 4 shows that S1, S2 and S3 who were studying in a private school, gave an correct answer to the first question on "Photosynthesis", and whose overall grade point averages were at the "Very Good" level used the metacognitive skills including re-reading, underlining the words while reading, re-examining the shape, marking the explanations in the text of the question, marking the options, marking the shape, and eliminating the options. The findings revealed that S4, who was studying in a private school, who gave a correct answer to the question, and whose overall grade point average was at the "Good" level, and S5 who was studying in a public school and whose overall grade point average was at the "Good" level used the metacognitive strategies including re-reading, re-examining the shape, marking the explanations in the text of the question, marking the options, marking the shape, and eliminating the options. Also, S6, who was who was studying in a public school, gave an incorrect answer to the question, and whose overall grade point average was at the "Fair" level, and S7 and S8 whose level average whose overall grade point averages were at the "Poor" level used the metacognitive strategy described as re-examining the shape.

Table 4 shows that S2, S2 and S3 who gave a correct answer to the first multiple-choice question, and whose overall grade point averages were at the "Very Good" level ; S4, whose overall grade point average was at the "Good" level, and S5 who was studying in a public school and whose overall grade point average was at the "Good" level used

metacognitive strategies including re-reading, underlining the words while reading, re-examining the shape, marking the explanations in the text of the question, marking the options, marking the shape, and eliminating the options; these strategies showed differences with the strategies used by S6, S7 and S8 who gave an incorrect answer to the multiple-choice question and whose levels of field knowledge were at the "Good" and "Poor" levels.

Table 4 demonstrates that that S1, S2 and S3 who were studying in a private school, whose overall grade point averages were at the "Very Good" level, and who gave a correct answer to first multiple-choice question, used more metacognitive strategies in terms of number and diversity compared to S4 and S5 who were studying in a private school and a public school, whose overall grade point averages were at the "Good" level, and who gave a correct answer to the question.

Table 4 also shows that S1, S2 S3, S4 and S5 who were studying in private and public schools and whose overall grade point averages were at "Very Good" and "Good" levels, and who gave a correct answer to the first multiple-choice question used more metacognitive strategies in terms of number and diversity compared to S6, S7 and S8 who were studying in a public school, whose overall grade point averages were at the "Fair" and "Poor" levels, and who gave an incorrect answer to the first question.

Table 5 presents the cognitive strategies used by 8th-grade students who were studying in a private and public school, and had different levels of overall grade point averages, and who answered the 2nd question on "Respiration" correctly and incorrectly.

Table 5: The Cognitive Strategies Used by the Students with Different Levels Overall Grade Point Averages and Answered the 2nd Question on "Respiration" Correctly or Incorrectly

2nd Question								
Schools	**Private School**				**Public School**			
Students	S1	S2	S3	S4	S5	S6	S7	S8
Answers	C	C	C	C	C	IC	IC	IC
Level of Overall Grade Point Average	VG	VG	VG	G	G	F	P	P
Cognitive Strategies								
Visualizing	√	√	√	√	√			
Reading while tracking words with a pencil						√		
Starting to Read the Question from the Root	√	√	√	√	√			
Underlining the Words While Reading	√	√	√	√	√			
Rephrasing Questions with Own Words	√	√	√	√	√			
Thinking About the Question	√	√	√	√	√	√	√	√
Increasing the Reading Speed	√	√	√					
Interpreting the Graph	√	√	√					
Examination								
Examining the Graph	√	√	√	√	√	√	√	√
Comparison								
Comparing the Options with the Explanations Given in the Text of the Question	√	√	√					
Comparing the Options with the Graph Given in the Text of the Question	√	√	√					

Comparing the Explanations Given in the Text of the Question with the Graph	√	√	√	√	√			

Table 5 shows that S1, S2 and S3 who were studying in a private school, gave a correct answer to the second question on "Respiration", and whose overall grade point averages were at the "Very Good" level used the cognitive skills including visualizing , starting to read the question from the root underlining the words while reading, rephrasing questions with own words, thinking about the question, increasing the reading speed, interpreting the graph, examining the graph, comparing the options and the explanations given in the text of the question, comparing the options with the graph given in the text of the question, and comparing the explanations given in the text of the question with the graph.

The findings revealed that S4, who was studying in a private school, gave a correct answer to the question, and whose overall grade point average was at the "Good" level, and S5 who was studying in a public school and whose overall grade point average was at the "Good" level used the cognitive strategies including visualizing , starting to read the question from the root, underlining the words while reading, rephrasing questions with own words, thinking about the question, examining the graph and comparing the explanations given in the text of the question with the graph. Also, S6, who was who was studying in a public school, gave a correct answer to the question and whose overall grade point average was at the "Fair" level used cognitive strategies such as reading while tracking words with a pencil, thinking about the question and examining the graph while solving the question. Lastly, S7 and S8 whose overall grade point average were at the "Poor" level used cognitive strategies such as thinking about the question and examining the shape.

Table 5 reveals that S2, S2 and S3 who gave a correct answer to the second multiple-choice question, and whose overall grade point averages were at the "Very Good" level ; S4, whose overall grade point average was at the "Good" level, and S5 who was studying in a public school and whose overall grade point average was at the "Good" level used cognitive strategies including visualizing, starting to read the question from the root, underlining the words while reading, rephrasing questions with own words, increasing the reading speed, interpreting the graph, comparing the options with the explanations given in the text of the question, comparing the options with the graph given in the text of the question, and comparing the explanations given in the text of the question with the graph. These cognitive strategies showed differences with the strategies used by S6, S7 and S8 who gave an incorrect answer to the multiple-choice question and whose overall grade point averages were at the "Good" and "Poor" levels. Table 5 also shows that S1, S2 and S3 who were studying in a private school and whose overall grade point averages were at the "Very Good" level, used more cognitive strategies in terms of number and diversity compared to S4 and S5 who were studying in a private and a public school, whose overall grade point averages were at the "Good" level, and who gave a correct answer to the question.

Table 5 demonstrates that S1, S2 S3, S4 and S5 who were studying in private and public schools and whose overall grade point averages were at "Very Good" and "Good" levels, and who gave a correct answer to the question used more metacognitive strategies in terms of number and diversity compared to S6, S7 and S8 who were studying in a public school, whose overall grade point averages were at the "Fair" and "Poor" levels, and who gave an incorrect answer to the second question.

Table 6 presents the metacognitive strategies used by 8th grade students who were studying in a private and a public school, and had different levels of overall grade point averages, and who answered the 2nd question on "Respiration" correctly and incorrectly.

Table 6: The Metacognitive Strategies Used by the Students with Different Levels Overall Grade Point Averages and Answered the 2nd Question on "Respiration" Correctly or Incorrectly

2nd Question								
Schools	**Private School**				**Public School**			
Students	S1	S2	S3	S4	S5	S6	S7	S8
Answers	C	C	C	C	C	IC	IC	IC
Level of Average (General) Academic Achievement	VG	VG	VG	G	G	F	B	B
Metacognitive Strategies								
Re-reading	√	√	√	√	√	√		
Underlining the Words While Reading	√	√	√	√	√			
Re-checking the Options	√	√	√	√	√			
Re-Checking Whether the Preferred Option is Correct	√	√	√					
Repeating the Hints	√	√	√					
Underlining the Hints	√	√	√	√	√			
Drawing Circles that Cover Hints	√	√	√	√	√			
Note-Taking	√	√	√	√	√			
Taking Notes on the Graph	√	√	√					
Re-Examination								
Re-examining the Graph	√	√	√	√	√	√	√	√
Marking								
Marking the Explanations in the Text of the Question	√	√	√	√	√			
Marking the Options	√	√	√	√	√			
Marking the Graph	√	√	√					
Eliminating the Options	√	√	√	√	√			

Table 6 shows that S1, S2 and S3 who were studying in a private school, gave a correct answer to the second multiple-choice question on "Respiration", and whose overall grade point averages were at the "Very Good" level used the metacognitive skills including re-reading, underlining the words while reading, re-checking the options, re-checking whether the preferred option is correct, underlining the hints, drawing circles that cover hints, note-taking, taking notes on the graph, re-examining the graph, marking the explanations given in the text of the question, marking the options, marking the graph, and eliminating options. The findings revealed that S4, who was studying in a private school, who gave a correct answer to the question, and whose overall grade point average was at the "Good" level, and S5 who was studying in a public school and whose overall

grade point average was at the "Good" level used the metacognitive strategies including re-reading, underlining the words while reading, re-checking the options, underlining the hints, drawing circles that cover hints, note-taking, re-examining the graph, marking the explanations given in the text of the question, marking the options and eliminating options. Furthermore, S6, who was who was studying in a public school, gave an incorrect answer to the question, and whose overall grade point average was at the "Fair" level used the metacognitive strategies such as re-reading and re-examining the graph. Lastly, S7 and S8 whose level average whose overall grade point averages were at the "Poor" level used the metacognitive strategy described as re-examining the graph.

Table 6 reveals that S2, S2 and S3 who gave a correct answer to the second multiple-choice question, and whose overall grade point averages were at the "Very Good" level ; S4, whose overall grade point average was at the "Good" level, and S5 who was studying in a public school and whose overall grade point average was at the "Good" level used metacognitive strategies including underlining the words while reading, re-checking the options, re-checking whether the preferred option is correct, underlining the hints, drawing circles that cover hints, note-taking, taking notes on the graph, marking the explanations given in the text of the question, marking the options, marking the graph, and eliminating options. These metacognitive strategies showed differences with the strategies used by S6, S7 and S8 who gave an incorrect answer to the multiple-choice question and whose overall grade point averages were at the "Good" and "Poor" levels. Table 6 also shows that S1, S2 and S3 who were studying in a private school and whose overall grade point averages were at the "Very Good" level, used more metacognitive strategies in terms of number and diversity compared to S4 and S5 who were studying in a private and a public school, whose overall grade point averages were at the "Good" level, and who gave a correct answer to the question.

Table 6 demonstrates that S1, S2 S3, S4 and S5 who were studying in private and public schools and whose overall grade point averages were at "Very Good" and "Good" levels, and who gave a correct answer to the second question used more metacognitive strategies in terms of number and diversity compared to S6, S7 and S8 who were studying in a public school, whose overall grade point averages were at the "Fair" and "Poor" levels, and who gave an incorrect answer to the second question.

The results of the research study can be summarized as follows;

The results of the study revealed that students who were studying in a private school who gave a correct answer to the first multiple-choice question, whose overall grade point averages were at the "Very Good" level, and students who gave a correct answer to the first multiple-choice question, who were studying in a private and a public school, and whose overall grade point averages were at the "Good" level used different strategies compared to the students who were studying in a public school, who gave an incorrect answer to the question, and whose overall grade point averages were at the "Fair" and "Poor" levels. The cognitive strategies used by the first group of students included Visualizing, starting to read the question from the root, underlining the words while reading, rephrasing questions with own words, note-taking, interpreting the shape,

comparing the options with the explanations given in the text of the question, comparing the options with the shape given in the text of the question; on the other hand, the metacognitive strategies included re-reading, underlining the words while reading, re-checking the options, marking the explanations in the text of the question, marking the options, marking the shape, and eliminating the options.

Furthermore, the results of the study revealed that students who were studying in a private school who gave a correct answer to the second multiple-choice question, whose overall grade point averages were at the "Very Good" level, and students who gave a correct answer to the second multiple-choice question, who were studying in a private and a public school, and whose overall grade point averages were at the "Good" level used different strategies compared to the students who were studying in a public school, who gave an incorrect answer to the question, and whose overall grade point averages were at the "Fair" and "Poor" levels. The cognitive strategies used by the first group of students included visualizing , starting to read the question from the root underlining the words while reading, rephrasing questions with own words, increasing the reading speed, interpreting the graph, comparing the options with the explanations given in the text of the question, comparing the options with the graph given in the text of the question, and comparing the explanations given in the text of the question with the graph; on the other hand, the metacognitive strategies included re-reading, underlining the words while reading, re-checking the options, re-checking whether the preferred option is correct, underlining the hints, drawing circles that cover hints, note-taking, taking notes on the graph, marking the explanations given in the text of the question, marking the options, marking the graph, and eliminating options.

In the literature, there are research studies that support the results of this study. The study conducted by Karatas & Guven (2003) found that students used the cognitive strategies such as drawing shapes and rephrasing questions with own words while solving questions; and Calıskan, Selcuk Sezgin, & Erol (2006) revealed that students used the cognitive strategies such as visualizing, writing down the main points of the question and main requirements, underlining the requirements, trying to understand, reading each sentence one by one, and illustrating the main points of the question by drawing a shape. Karacam (2009) indicated that prospective teachers used cognitive strategies such as repeating the answer aloud, visualizing, reflecting the problem on behaviours, rephrasing questions with own words, note-taking, and examining the shape after reading to solve the questions. The study conducted by Diken (2014) revealed that students used cognitive strategies such as reading while tracking words with a pencil, starting to read the question from the root, rethinking the question in the context of real-life, thinking about the operations needs to be performed to solve the questions, reflecting the main points of the question on a shape, comparing the shapes, comparing the explanations given in the text of the question, comparing options with the shapes given in the text of the question, comparing the options and the explanations given in the text of the question, examining the shapes, and examining the graphs to solve the multiple-choice questions in the field of life sciences. Tutar, Demir, & Diken (2020) pointed out that

12th grade students of a Science High School, and an Anatolian High School, who gave correct answers to the multiple-choice biology questions used different cognitive strategies compared to the students of the Anatolian High School who gave incorrect answers to the questions: these strategies included Visualizing , rephrasing questions with own words, note-taking, underlining the words while reading, comparing the explanations with shapes, graphs and tables given in the question, and asking oneself questions.

Goos, Galbraith, & Renshaw (2000) noted that students used metacognitive strategies to solve questions such as reading the problem for multiple-times, re-reading the problem to check whether the way of solving the question is right, asking themselves how close are they to solve the question, realizing that they need to re-consider the way of solving the question and trying a different approach, re-checking the operations to see if there is an error, re-reading the problem to think about the selected method (e.g. Could I reach the answer of the question asked in the problem?) and asking themselves whether the answer makes sense. Karacam (2009) found that prospective teachers used metacognitive strategies to solve questions including reading other answers, re-reading, reflecting the problem on behaviours, asking questions, and expressing themselves with their own words.

The study conducted by Diken (2014) determined that students used metacognitive strategies such as rereading, repeating the important points, underlining the hints, drawing circles that cover the hints, reading other options, drawing shapes, marking the options, marking the explanations given in the text of the question, and eliminating the options. Tutar, Demir, & Diken (2020) found that students of a Science High School, and an Anatolian High School, who gave correct answers to the multiple-choice biology questions used different metacognitive strategies compared to the students of the Anatolian High School who gave incorrect answers to the questions: these strategies included note-taking, underlining the hints or drawing circles that cover the hints, marking the explanations given in the text of the question, repeating the important points, marking the shapes, tables or graphs given in the text of the question, eliminating the options, and underlining the words while reading.

The results of the study revealed that students who were studying in a private school, whose overall grade point averages were at the "Very Good" level, who gave a correct answer to the first multiple-choice question used more cognitive and metacognitive strategies in terms of number and diversity compared to the students who were studying in a private and a public school, whose overall grade point averages were at the "Good" level, and who gave a correct answer to the question. The results also showed that students who were studying in a private or a public school, whose overall grade point averages were at the "Very Good" and "Good" levels, and who gave a correct answer to the question used more cognitive and metacognitive strategies in terms of number and diversity compared to the students who were studying in a public school, whose overall grade point averages were at the "Fair" and "Poor" levels, and who gave an incorrect answer to the first question. The study found out that students who were

studying in a private school, whose overall grade point averages were at the "Very Good" level, and who answered the second multiple-choice question correctly used more cognitive and metacognitive strategies compared to the students who were studying in a public and a private school, whose overall grade point averages were at the "Good" level, and who gave a correct answer to the question. Furthermore, the study results also showed that students who were studying in a private or a public school, whose overall grade point averages were at the "Very Good" and "Good" levels, and who gave a correct answer to the question used more cognitive and metacognitive strategies in terms of number and diversity compared to the students who were studying in a public school, whose overall grade point averages were at the "Fair" and "Poor" levels, and who gave an incorrect answer to the second question.

The study conducted by Diken & Yuruk (2019) pointed out that students of the Science High School and Anatolian High School used more cognitive and metacognitive strategies in terms of number and diversity before, during and after solving multiple-choice biology questions compared to students of Anatolian and Vocational High School students who gave an incorrect answer to the question. The study also revealed that some of the students who were studying in Anatolian and Vocational High Schools could not solve the biology question and left the question blank, and they did not use any cognitive or metacognitive strategies since they gave up. The study of Tutar, Demir, & Diken (2020) noted that students who answered the multiple-choice questions correctly used more cognitive and metacognitive strategies in number and diversity compared to the students who answered the questions incorrectly.

5. Recommendations

As a result of these investigations, suggestions were identified for future research.

1) The study focused on cognitive and metacognitive strategies were used by 8th-grade students, who were studying in a private and a public school, to solve multiple-choice questions in the field of biology. The study identified that the use of a large number and diverse range of strategies is an important factor that enables students to reach the correct answer.
2) In line with the results of this study, the cognitive and metacognitive strategies that were used by students, who were studying in a private and public school, who had a high level of overall grade point averages, and who gave correct answers to the question, to solve the multiple-choice questions in the field of biology could be introduced to students at all levels. Students could be guided to read and solve a multiple-choice question by using these cognitive and metacognitive strategies, and in this way, their abilities to reach the correct answer to the question can be enhanced.
3) The study identified that the 8th grade students who were studying in a private and a public school, who had a high level of overall grade point averages, and who gave correct answers to the question continued to use strategies while solving the

multiple-choice questions, and answered the questions correctly; on the other hand, students who were studying in a public school and had a low level of overall grade point averages gave incorrect answers to the questions, and they used a small number of strategies, or they did not use any strategies at all. Based on these results, the outcomes of the instruction provided to the studies to encourage them to solve the question, and to continue using strategies could be analysed.

4) The study revealed that the level of overall grade point averages of the students was associated with the number and types of the cognitive and metacognitive strategies used by the students to solve the multiple-choice questions. Students who had had a high level of overall grade point averages used a large number and diverse range of strategies. This result points out to the fact that students are required to use appropriate cognitive and metacognitive strategies for solving multiple-choice questions and should not give up while trying to solve these questions.

6. Conclusion

This study has shown that 8th grade students who were studying in a private and a public school, who had a high level of overall grade point averages and who answered the multiple-choice biology questions correctly used a large number and diverse range of cognitive and metacognitive strategies in comparison to the 8th grade students who were studying in a public school and had a low level of overall grade point average.

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About the Author
Emine Hatun Diken completed her graduate, master and PhD studies at Gazi University. She is working at Kafkas University. She has scientific publications in various journals. She is currently working on science and biology education.

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