SOURCES OF STRATEGIES EMPLOYED BY 8TH GRADE STUDENTS WHEN SOLVING MULTIPLE CHOICE SCIENCE QUESTIONS

(Research article)

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Abstract

This study was conducted to reveal the sources of strategies employed by 8th grade students when solving multiple choice science questions. The holistic multiple-case study, which is one of the qualitative research approaches, was used for this study. A total of eight students, four 8th grade students from a private secondary school in Kars city center and four 8th grade students from a public secondary school, voluntarily participated in the study. A total of three questions from the 8th grade science curriculum, one question each from the units of Electric Charges and Electrical Energy, Matter and Industry, Energy Conversions and Environmental Pollution, were used as the data collection tools of this study. Another data collection tool used in the study was a semi-structured questionnaire. Students solved the questions using Think Aloud Strategy. Problem solving process of the students was observed through camera recordings. This helped to determine the cognitive/meta-cognitive strategies that students employed while solving questions. Subsequently a semi-structured questionnaire was administered to confirm whether the strategies employed while solving the questions were either a cognitive or meta-cognitive strategy and to identify the sources of the strategies (from whom, where and how they learned these strategies). Camera recordings of the question solving processes and the semi-structured interviews were then analyzed. The data were analyzed with a computer program used in the analysis of qualitative research. The results of the research indicated that the sources of cognitive/meta-cognitive strategies employed by students whose 8th grade science course grade point average (GPA) is "Very Good" and who answered the questions correctly are themselves, the sources of cognitive/meta-cognitive strategies employed by students whose 8th grade science course GPA is "Good" and who answered the questions correctly were predominantly themselves and rarely their teachers. The sources of cognitive/meta-cognitive strategies employed by students whose 8th grade science course grade point average is "Average" and who answered the questions wrong were rarely themselves and predominantly their teachers and friends whereas the sources of cognitive/meta-cognitive strategies employed by students whose grade point average were "Poor" and "Very Low (Fail)" and who answered the questions wrong were predominantly their teachers and family (mom, dad, sister, brother).

Keywords: Sources of strategies; cognitive/meta-cognitive strategies; multiple choice science questions; 8. grade students

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1. Introduction

Today, individuals undertake many tasks and responsibilities in their professional (academic) and daily lives. The individuals need to overcome the related challenges while fulfilling their duties and responsibilities (Vaidya, 1999). Problem is a challenging situation that creates a desire to solve it when turns into mental confusion. It has no single standard solution as it is newly encountered and can be solved when the individual tries to solve it by directing the knowledge in the right direction (Turnuklu & Yeşildere, 2005). Mental confusion caused by problems can be overcome through problem solving. Problem solving is defined as to be able to find new solutions by simply applying the rules that individuals have acquired from their previous experiences (Korkut, 2002). Training individuals on problem solving is a really important issue. Providing training/education on a certain subject before giving students problems to be solved on this subject will facilitate the students' problem-solving processes (Gelbal, 1991). Both students and teachers need to use their problem-solving skills in order to develop all the mental abilities of students during the education process. For this reason, students need to be able to identify a problem, develop alternative solutions to the problem, and review possible outcomes. Designing teaching environments with this in mind will enable students to grow up as individuals with improved problem-solving skills (Sahin, 2004). Individuals with advanced problem-solving skills know problem-solving strategies well and can use them correctly. Flavell (1976, 1979) and Livingstone (1997) categorized problem solving strategies into two categories as cognitive and meta-cognitive strategies. Flavell (1976, 1979) and Livingstone (1997) defined a strategy employed to carry out mental operations in the problem solving process is a cognitive strategy. However, a strategy used to control, monitor or evaluate the solution process is meta-cognitive strategy. Problem solving has a key role in the field of science learning. The knowledge and skills that students need to solve science problems correctly can vary (Diken, 2014). Students' ability to correctly solve the problems in the field of science learning depends on the specific features and qualifications of the problems, students' knowledge in science as well as problem-solving strategies along with their past experiences of solving science problems (Taconis, Hessler & Broekkamp, 2001). Students' problem solving experience is in fact their awareness of whether they have learned the problem solution processes through their own experiences from past to present or from their teachers, friends or family members such as parents, sisters, brothers and sisters. This research aimed to determine the students' problem solving experiences in terms of strategies. It helped to identify where, from whom or how students learned the cognitive/meta-cognitive strategies they employed while solving problems in the field of science learning, in other words, the sources of strategies. The reason for conducting this research is to have an idea about whether the cognitive/meta-cognitive strategies that students use when solving questions in the field of science learning should firstly be further taught to students themselves, teachers or students' family members.

2. Method

2.1. Purpose of the study

This study was conducted to reveal the sources of cognitive/meta-cognitive strategies employed by 8th grade secondary school students while solving multiple choice science questions, that is, from whom, where and how they learned these strategies.

2.2. Study Design

"Case study" approach of the qualitative research techniques was used for this study. The research was further customized as a "holistic multiple-case study" (Yin, 2003) as each situation is compared with each other (Yildirim & Simsek, 2021) and evaluated holistically.

2.3. Participants

A total of eight students, four 8th grade students from a private secondary school in Kars city center and four 8th grade students from a public secondary school, voluntarily participated in the study. These students were determined on a voluntary basis and based on the "maximum diversity sampling method" put forward by Patton (2002).

The science course grade point average ranges of the 8th grade students participating in the research and the corresponding success levels are presented in Table 1 based on the Ministry of National Education Regulation on Secondary Education Institutions (MoNE, 2019).

Table 1. Grade point average ranges of the students and corresponding success levels (MoNE)

GPA	SUCCESS LEVEL
85.00-100	Very Good
70.00-84.99	Good
60.00-69.99	Average
50.00-59.99	Poor
0-49.99	Very Low (Fail)

Table 1 reveals that 8th grade students whose grade point average in the science course were between 85.00-100 were evaluated as "Very Good", those with a GPA between 70.00-84.99 were evaluated as "Good", 60.00-69.99 were evaluated as "Average", 50.00-59.99 were evaluated as "Poor" and those with a GPA between 00.00-49.99 were evaluated as "Very Low (Fail)" based on the Ministry of National Education Regulation on Secondary Education Institutions (MoNE, 2019).

Table 2 presents the pseudonyms assigned to 8th grade students participating in the research, the type of the secondary school they are enrolled, their grade point average in science course and the success levels corresponding to these GPAs.

Table 2. Students' grade point average and success level in science courses

SCHOOL TYPE	STUDENTS	SCIENCE COURSE GPA	SUCCESS LEVEL
PRIVATE SCHOOL	S1	98	Very Good
	S2	96	Very Good
	S3	82	Good
	S4	76	Good
STATE SCHOOL	S5	67	Average
	S6	59	Poor
	S7	53	Poor
	S8	41	Very Low (Fail)

Table 2 reveals that among the four private secondary school students who participated in the research conducted within the scope of the Ministry of National Education Regulation on Secondary Education Institutions (MoNE, 2019), success levels of S1 and S2 whose grade point average in the 8th grade science course were 98 and 96 respectively and these two students were evaluated as "Very Good". On the other hand among the four state secondary school students who participated in the research, success level of S5 who scored 67 in the science course was evaluated as "Average"; success levels of S6 and S7 whose grade point average were 59 and 53 respectively were evaluated as "Poor" whereas success level of S8 who scored 41 was evaluated as "Very Low (Fail)". A total of eight students were included in the research in accordance with the above criteria.

2.4. Data collection tools

2.4.1. Multiple choice science questions

A total of three multiple-choice science questions (one question each from the disciplines of physics, chemistry and biology) were used from three units of the 8th grade science course curriculum for the purpose of the research. First question was related to the "Electric Charges and Electrical Energy" unit with 11 learning outcomes under the "Physical Events" learning area of the 8th grade science course curriculum. Second question was related to the "Matter and Industry" unit with 17 learning outcomes under the "Matter and Nature" learning area. Second question was related to the "Energy Conversions and Environmental Science" unit with 17 learning outcomes under the "Living Things and Life" learning area. Authors paid

strict attention to pick up questions from units with high learning outcomes and a high probability of being asked in the High School Entrance Exams. The opinions of science teachers were asked, too, while choosing the questions. Furthermore the opinions of authors who have previously studied on the strategies were also taken to select questions where students may tend to use multiple strategies within a wide variety. The questions were selected from the High School Entrance Exam preparation books. Therefore, these are questions whose validity and reliability have been previously confirmed. The questions were then checked by three professors who have studied in the fields of Physics, Chemistry and Biology for years to reconfirm that the questions had no misinformation or misconceptions.

The students were instructed to solve these three multiple choice questions, one each from the physics, chemistry and biology disciplines of the 8th grade science course curriculum using Think Aloud Strategy. Think Aloud Strategy is one of the techniques used to detect the interactions between students' performance in solving a question or problem and the different factors affecting the solution of the question or problem (Van Someren, Barnard & Sandberg, 1994). Observations through the Think Aloud session helped to identify the strategies that students used in solving the questions.

2.4.2. Semi-structured interview questions

Each student was asked two semi-structured interview questions after solving each question to reaffirm the cognitive/meta-cognitive classification of strategies employed by students in the process of solving multiple choice questions from the science learning area and to determine from whom, where or how students have learned these strategies, that is, the sources of cognitive/meta-cognitive strategies. Interview questions were developed by "Diken and Yuruk (2020), Diken (2014)".

The two questions developed by "Diken and Yuruk (2014) and Diken (2020)" were as follows:

What did you do while solving the question (encircling the clues, checking the solution process etc.)? Why did you do that?

What is the source of the strategies you employed while solving the question (encircling the clues, check the solution process etc.)? Where, how or from whom did you learn these strategies?

2.5. Research Process

A total of three questions, one from each of the learning areas of Physics, Chemistry and Biology, was decided to be used in research.

Three professors who have studied in the fields of Physics, Chemistry and Biology were asked to check the questions to reconfirm that the questions had no misinformation or misconceptions; accordingly the questions were rectified according to the feedback given.

Students who wanted to participate in the research were nominated by asking the science teachers of the secondary schools where the study was conducted.

Secondary school administrators, teachers and students in the study group were duly informed about the research process.

Students were further informed about the Think Aloud Strategy before solving the multiple-choice questions.

Students were then asked to solve the questions using the Think Aloud Strategy and their question-solving sessions were recorded with a camera in order to determine the cognitive/meta-cognitive strategies employed by students while solving multiple choice questions and the sources of these strategies.

Following the problem solving processes and the semi-structured interviews conducted with the students after solving the questions, the author checked once again whether there were any deficiencies in the research process.

Research data were analyzed by reviewing the camera recordings of the students' problem solving session using the Think Aloud Strategy and the semi-structured interviews held thereafter.

2.5. Analysis of Data

Observations on the students' problem solving session using the Think Aloud Strategy along with the data compiled from the transcripts of the written records of the semi-structured interviews were categorized in order to identify the cognitive/meta-cognitive strategies that students used while solving multiple-choice science questions along with the sources of these strategies. The analyzes of the transcripts were coded in a computer program used in the analysis of qualitative research.

The author sought the consultancy of a professor who had prior studies on the relevant subject and has sufficient expertise to categorize the strategies as cognitive/meta-cognitive and to confirm the consistency and reliability of the codes developed about the sources of these strategies. Then the data set of a student's problem solving session was further coded by another professor who had previously studied this subject. The consistency between the codes developed by the author and the coding made by the professor was found as 97%. The author and the professor who had sufficient expertise on the subject had discussions and exchanged their ideas about the inconsistent codes and reached a common understanding on the final codes.

The findings obtained from the data analysis were presented in tables and further explained below.

3. Results

The tables and explanations with regard to the findings obtained from this research, which aims to identify the sources of cognitive and meta-cognitive strategies employed by 8th grade students while solving multiple-choice science questions, are as follows.

The findings with regard to the cognitive strategies obtained while solving the physics question and the sources of these strategies are presented in Table 3.

Table 3. Cognitive strategies employed in solving physics questions and sources of strategies

PHYSICS QUESTION								
SECONDARY SCHOOL	PRIVATE SCHOOL				STATE SCHOOL			
STUDENTS	S1	S2	S3	S4	S5	S6	S7	S8
ANSWER	C	C	C	C	W	W	W	B
SUCCESS LEVELS OF GPAs	VG	VG	G	G	AVE	PO	PO	F
COGNITIVE STRATEGIES								
Visualization	S	S	S	S				
Reading starting from the root of the problem	S			S	F			
Note-taking	S	S	T	T			T	
Asking oneself questions		S	S			S	S	
Expressing in one's own words	S	S	S	S	S			
Reading with underlining words	S	S	S			FM	T	
Reading while tracing the words with a pen				S	FM	FM	FM	
Trial and error	S	S	S	S				
COMPARISON								
Comparing the figures with options	S	S	S	S	T	T		
EXAMINATION								
Examining the figures	S	S	S	T	S	T	T	
ELIMINATION								
Eliminating the options	S	S	S	S				

Table 3 revealed that S1 and S2, who were studying at a Private Secondary School, who answered the Physics question correctly and achieved a "Very Good (VG)" success level corresponding to the GPA they received from the science course, employed the cognitive strategies of visualization, reading starting from the root of the problem, note-taking, asking oneself questions, expressing in one's own words, reading with underlining words, trial and error, comparing the figures with options and eliminating the options. It was further determined that they developed these strategies themselves by solving questions, that is, they were the source of the cognitive strategies they used while solving the questions (S). S3, who was studying at a Private Secondary School, who answered the question correctly and achieved a "Good (G)" success level corresponding to the GPA, employed the cognitive

strategies of visualization, asking oneself questions, expressing in one's own words, reading with underlining words, trial and error, comparing the figures with options, examining the figures and eliminating the options. It was further determined that he developed these strategies himself by solving questions, that is, he was the source of the cognitive strategies employed while solving the questions were themselves (S). S3 was further determined to have learned the note-taking cognitive strategy from his teacher. S4, who was studying at a Private Secondary School, who answered the question correctly and achieved a "Good (G)" success level corresponding to the GPA, employed the cognitive strategies of reading starting from the root of the problem, expressing in one's own words, reading with underlining words, trial and error, comparing the figures with options and eliminating the options. It was further determined that she developed these strategies herself by solving questions, that is, he was the source of the cognitive strategies employed while solving the questions were themselves (S). S4 was further determined to have learned the note-taking and examining the figures cognitive strategy from her teacher.

Table 3 further revealed that S5, who was studying at a State Secondary School, who answered the Physics question wrong (W) and achieved an "Average (AVE)" success level corresponding to his GPA, employed the cognitive strategies of expressing in one's own words and examining the figures which he learned himself by solving questions, comparing the figures with options which he learned from his teacher (T), reading starting from the root of the problem which he learned from his friend (F) and reading while tracing the words with a pen which he learned from his family members (mom, dad, sister and brother) (FM). It was determined that S5, who was studying at a State Secondary School, who answered the question wrong (W) and achieved a "Poor (P)" success level corresponding to his GPA, employed the cognitive strategies of asking oneself questions which he learned himself by solving questions, reading with underlining words and reading while tracing the words with a pen which he learned from his family members (FM) as well as comparing the figures with options and examining the figures which he learned from his teacher (T). S7, who was studying at a State Secondary School, who answered the question wrong (W) and achieved a "Poor (P)" success level corresponding to her GPA, employed the cognitive strategies of asking oneself questions which she learned herself by solving questions, note-taking, reading with underlining words and examining the figures strategies which she learned from her teacher and the reading while tracing the words with a pen strategy which she learned from her family members (mom, dad, sister and brother) (FM). S8, who was studying at a State Secondary School and achieved a "Very Low (Fail) (F)" success level corresponding to his GPA, could not solve the physics question and left it blank (B); therefore it was determined that he did not use any cognitive strategies and cognitive strategy sources.

The findings with regard to the meta-cognitive strategies obtained while solving the physics question and the sources of these strategies are presented in Table 4.

Table 4. Meta-cognitive strategies employed in solving physics questions and sources of strategies

PHYSICS QUESTION								
SECONDARY SCHOOL	PRIVATE SCHOOL				STATE SCHOOL			
STUDENTS	S1	S2	S3	S4	S5	S6	S7	S8
ANSWER	C	W	C	C	W	W	W	B
SUCCESS LEVELS OF GPAs	VG	VG	G	G	AVE	PO	PO	F
META-COGNITIVE STRATEGIES								
Re-Reading				T	T	T	T	
Repeating the Highlights	S	S	S	S				
Reflecting the problem in one's behavior	S	S	S	S				
Increasing the reading speed					T			
Asking oneself questions		S	S	S	S			
Underlining Clues	S	S	T	T				
Encircling the clues	S	S	T	T				
Backtracking	S	S	S	S				
MARKING								
Marking the figure	S	S	S	S	F		FM	
Marking the options	S	S	S	S				
REVIEW								
Reviewing the Figure	S	S	T	S	T	T	FM	

Table 4 revealed that S1 and S2, who were studying at a Private Secondary School, who answered the Physics question correctly and achieved a "Very Good (VG)" success level corresponding to the GPA they received from the science course, employed the meta-cognitive strategies of repeating the highlights, reflecting the problem in one's behavior, underlining clues, encircling the clues, backtracking, marking the figure, marking the options and reviewing the figure. It was further determined that they developed these strategies themselves by solving questions, that is, they were the source of these meta- cognitive strategies employed while solving the questions (S). S2 was further determined to have developed the meta-cognitive strategy of asking oneself questions herself by solving questions. S3 and S4, who were studying at a Private Secondary School, who answered the Physics question correctly and achieved a "Good (G)" success level corresponding to the GPA they received from the science course, were determined to have employed the meta-cognitive strategies of repeating the highlights, reflecting the problem in one's behavior, asking oneself questions, marking the

figure and marking the options and that they developed these strategies themselves by solving questions, that is, they were the source of the meta-cognitive strategies used while solving the questions (S). S3 and S4 were determined to have learned the meta-cognitive strategies of underlining and encircling the clues from their teachers. S4 was further determined to have developed the meta-cognitive strategy of reviewing the figure herself by solving questions. S3 was also determined to have developed the reviewing the figure meta-cognitive strategy himself by solving questions.

S5, who was studying at a State Secondary School, who answered the Physics question wrong (W) and achieved an "Average (AVE)" success level corresponding to his GPA, S6 with a "Poor (P)" success level and S7 were determined to have employed the re-reading meta-cognitive strategy which they learned from their teacher (T). S5, who was studying at a State Secondary School, who answered the question wrong (W), who achieved an "Average (AVE)" success level corresponding to his GPA and S6 were further determined to have employed the increasing the reading speed and reviewing the figure meta-cognitive strategies which they learned from their teacher (T). It was also determined that S5 learned the asking oneself questions meta-cognitive strategy himself by solving questions and the marking the figure meta-cognitive strategy of marking the figure from his friend. S7, who was studying at a State Secondary School, who answered the question wrong (W) and achieved a "Poor (P)" success level, was determined to have learned the marking the figure and reviewing the figure meta-cognitive strategies from her family members (mom, dad, sister and brother) (FM). S8, who was studying at a State Secondary School and achieved a "Very Low (Fail)" success level could not solve the physics question and left it blank (B); therefore, it was determined that he did not use any cognitive strategies and cognitive strategy sources.

The findings with regard to the cognitive strategies obtained while solving the chemistry question and the sources of these strategies are presented in Table 5.

Table 5. Cognitive Strategies Employed in Solving Chemistry Questions and Sources of Strategies

CHEMISTRY QUESTION								
SECONDARY SCHOOL	PRIVATE SCHOOL				STATE SCHOOL			
STUDENTS	S1	S2	S3	S4	S5	S6	S7	S8
ANSWER	C	C	C	C	W	W	W	B
SUCCESS LEVELS OF GPAs	VG	VG	G	G	AVE	PO	PO	F
COGNITIVE STRATEGIES								
Visualization	S	S	S	S				
Reading starting from the root of the problem	S	S	T	S	F			
Note-taking	S	T	T	T	F		T	
Asking oneself questions		S	S			FM		
Expressing in one's own words	S	S		S				
Reading with underlining words	S	S						

Reading while tracing the words with a pen			S	S	S	FM	FM	
Trial and error		S	S	S				
COMPARISON								
Comparing the descriptions in the text	S	S	S		T			
Comparing the descriptions in the text with the options	S	S	S	S				
Comparing options	S	S	S					
ELIMINATION								
Eliminating the options	S	S	S	S				

Table 5 revealed that S1 and S2, who were studying at a Private Secondary School, who answered the Chemistry question correctly and achieved a "Very Good (VG)" success level corresponding to the GPA they received from the science course, employed the cognitive strategies of visualization, reading starting from the root of the problem, expressing in one's own words, reading with underlining words, comparing the descriptions in the text, comparing the descriptions in the text with the options, comparing options and eliminating the options which they developed themselves by solving questions, that is, they were the source of the cognitive strategies they used while solving the questions (S). While solving the question, S2 was also determined to have used the cognitive strategies of asking oneself questions as well as trial and error, which she learned herself by solving questions. S2 was further determined to have learned the note-taking cognitive strategy from his teacher. S3 and S4, who were studying at a Private Secondary School, who answered the question correctly and achieved a "Very Good (VG)" success level corresponding to the GPA, employed the cognitive strategies of visualization, reading with underlining words, trial and error, comparing the descriptions in the text with the options and eliminating the options which they developed themselves by solving questions, that is, they were the source of the cognitive strategies they used while solving the questions (S). S3 was further determined to have employed the asking oneself questions, comparing the descriptions in the text and comparing options cognitive strategies which he learned himself by solving questions while S4 also learned the reading starting from the root of the problem and expressing in one's own words cognitive strategies on her own by solving problems. S1 and S2, who studied at the Private Secondary School, who answered the question correctly and achieved a "Very Good (VG)" success level corresponding to the GPA and S3 who answered the question correctly and achieved a "Good (G)" success level were determined to have learned the note-taking and reading starting from the root of the problem cognitive strategies from their teachers.

Table 5 further revealed that S5 who studied at the State Secondary School, who answered the Chemistry question wrong and achieved an "Average (AVE)" success level corresponding to the GPA was determined to have learned the reading while tracing the words with a pen cognitive strategy himself by solving questions; he learned the reading starting from the root of the problem and note-taking strategies from his friends and comparing the descriptions in the text strategy from his teacher. S6, who was studying at the State Secondary School, who

answered the question wrong (W) and achieved a "Poor (P)" success level, was determined to have learned the asking oneself questions and reading while tracing the words with a pen cognitive strategies from her family members (mom, dad, sister and brother). S7, who was studying at the State Secondary School, who answered the question wrong (W) and achieved a "Poor (P)" success level, was determined to have learned the note-taking strategy from her teacher whereas she learned reading while tracing the words with a pen cognitive strategy from her family members (mom, dad, sister and brother). S8, who was studying at the State Secondary School and achieved a "Very Low (Fail)" success level corresponding to his GPA, could not solve the chemistry question and left it blank; therefore it was determined that he did not use any cognitive strategies and cognitive strategy sources.

The findings with regard to the meta-cognitive strategies obtained while solving the chemistry question and the sources of these strategies are presented in Table 6.

Table 6. Meta-Cognitive Strategies Employed in Solving Chemistry Questions and Sources of Strategies

CHEMISTRY QUESTION								
SECONDARY SCHOOL	PRIVATE SCHOOL				STATE SCHOOL			
STUDENTS	S1	S2	S3	S4	S5	S6	S7	S8
ANSWER	C	C	C	C	W	W	W	B
SUCCESS LEVELS OF GPAs	VG	VG	G	G	AVE	PO	PO	F
META-COGNITIVE STRATEGIES								
Re-Reading	S	S			T	T	T	
Reviewing the process	S	S	T	T				
Repeating the Highlights	S	S	S	S				
Note-taking	S	T	T	T			T	
Reading while tracing the words with a pen	S			S	S	S	S	
Underlining Clues	S	S	T	T				
Encircling the clues	S	S	T	T				
MARKING								
Marking the descriptions in the text								
Marking the options	S	S	S	S	F			
REVIEW								
Reviewing the Options	S	S	T	S				

Table 6 revealed that S1 and S2, who were studying at the Private Secondary School, who answered the Chemistry question correctly and achieved a "Very Good (VG)" success level corresponding to the GPA they received from the science course, employed the meta-cognitive strategies of re-reading, reviewing the process, repeating the highlights, underlining clues, encircling the clues, marking the options and reviewing the options. It was further determined that they developed these strategies themselves by solving questions, that is, they were the source of these meta- cognitive strategies employed while solving the questions. S1 was

further determined that he developed reading while tracing the words with a pen strategy himself while S2 learned the note-taking meta- cognitive strategy from his teacher. S3 and S4, who were studying at the Private Secondary School, who answered the question correctly and achieved a "Very Good (VG)" success level corresponding to the GPA were determined to have developed the repeating the highlights and marking the options strategies themselves while solving questions whereas they learned reviewing the process, note-taking, underlining the clues and encircling the clues strategies from their teachers. S3 was further determined to have developed reviewing the options from his teacher while S4 learned reading while tracing the words strategy herself by solving questions. S5, studying at the State Secondary School, who answered the Chemistry question wrong and achieved an "Average (AVE)" success level corresponding to the GPA in science together with S6 and S7 who answered the question wrong and achieved a "Poor (P)" success level was determined to have learned the re-reading meta-cognitive strategy from their teachers and reading while tracing the words with a pen strategy themselves by solving questions. S5 was determined to have learned the marking the options strategy from his friends whereas S7 learned the note-taking meta-cognitive strategy from his teacher. S8, who was studying at the State Secondary School and achieved a "Very Low (Fail)" success level could not solve the question, gave up and left it blank; therefore it was determined that he did not use any meta-cognitive strategies and meta-cognitive strategy sources.

The findings with regard to the cognitive strategies obtained while solving the biology question and the sources of these strategies are presented in Table 7.

Table 7. Cognitive strategies employed in solving biology questions and sources of strategies

BIOLOGY QUESTION								
SECONDARY SCHOOL	PRIVATE SCHOOL				STATE SCHOOL			
STUDENTS	S1	S2	S3	S4	S5	S6	S7	S8
ANSWER	C	C	C	C	W	W	W	W
SUCCESS LEVELS OF GPAs	VG	VG	G	G	AVE	PO	PO	F
COGNITIVE STRATEGIES								
Visualization	S	S	S	S				
Reading starting from the root of the problem	S	S	S		F			
Expressing in one's own words	S		S	S				
Reading with underlining words	S	S	S					
Reading while tracing the words with a pen				S	S	S	S	F
REVIEW	S	S	T	T				
Reviewing the graphics	S	S	S	S	S	S	T	F
COMPARISON								
Comparing the graphics in the text with the options of the question	S	S	S	S				
ELIMINATION								
Eliminating the options	S	S	S	T				

Table 7 revealed that S1 and S2, who studied at the Private Secondary School, who answered the Biology question correctly and achieved a "Very Good (VG)" success level corresponding to their GPA, were determined to have learned the visualization, reading starting from the root, reading with underlining words, reviewing the graphics, comparing the graphics in the text with the options of the question and eliminating the options cognitive strategies themselves by solving questions. S1 was further determined to have developed the expressing in one's own words strategy himself by solving questions. S3 and S4, who studied at the Private Secondary School, who answered the question correctly and achieved a "Good (G)" success level corresponding to their GPA, were determined to have learned the visualization, expressing in one's own words, reviewing the graphics, comparing the graphics in the text with the options of the question cognitive strategies themselves by solving questions. S3 was further determined to have developed the reading starting from the root and reading with underlining words strategies himself by solving questions while S4, too, learned reading while tracing the words with a pen strategy herself by solving questions. S3 and S4 were determined to have learned reviewing the graphics cognitive strategy and S4 learned eliminating the options strategy from their teachers.

Table 7 revealed that S5 who studied at the State Secondary School, who answered the Biology question wrong and achieved an "Average (AVE)" success level corresponding to the GPA in science together with S6 who was also studying at the State Secondary School, who answered the question wrong and achieved a "Poor (P)" success level was determined to have learned the reading while tracing the words with a pen and reviewing the graphics cognitive strategies themselves by solving questions however S5 learned reading starting from the root strategy from his friends. S7, who was studying at the State Secondary School, who answered the question wrong and achieved a "Poor (P)" was determined to have learned the reading while tracing the words with a pen cognitive strategy herself by solving questions however she learned reviewing the graphics strategy from her teacher. S8, who was studying at the State Secondary School, answered the question wrong and achieved a "Very Low (Fail)" success level, on the other hand, was determined to have learned the reading while tracing the words with a pen and reviewing the graphics strategies from his friends.

The findings with regard to the meta-cognitive strategies obtained while solving the biology question and the sources of these strategies are presented in Table 8.

Table 8. Meta-cognitive strategies employed in solving biology questions and sources of strategies

BIOLOGY QUESTION								
SECONDARY SCHOOL	PRIVATE SCHOOL				STATE SCHOOL			
STUDENTS	S1	S2	S3	S4	S5	S6	S7	S8
ANSWER	C	C	C	C	W	W	W	W
SUCCESS LEVELS OF GPAs	VG	VG	G	G	AVE	PO	PO	F
META-COGNITIVE STRATEGIES								
Re-Reading			S	T	T	T	FM	FM
Repeating the Highlights	S	S	T	S				
Reading other options for verification	S	S	S	T				
Underlining Clues	S	S	S	T				
Encircling the clues	S	S	T	T				
MARKING								
Marking the graphics	S	S	S	S	F			
Marking the options	S	S	S	S				
REVIEW								
Reviewing the Graph	S	S	S	S	T	FM	T	FM

Table 8 revealed that S1 and S2, who were studying at a Private Secondary School, who answered the Biology question correctly and achieved a "Very Good (VG)" success level corresponding to the GPA they received from the science course, employed the meta-cognitive strategies of repeating the highlights, reading other options for verification, underlining clues, encircling the clues, marking the graphics, marking the options and reviewing the graph. It was further determined that they developed these strategies themselves by solving questions, that is, they were the source of these meta- cognitive strategies employed while solving the questions (S). S3 and S4, who studied at the Private Secondary School, who answered the question correctly and achieved a "Good (G)" success level corresponding to their GPA, were determined to have developed the marking the graphics, marking the options and reviewing the graphics meta-cognitive strategies themselves by solving questions and learned the encircling the clues strategies from their teachers. S3 was further determined to have developed the reading other options for verification strategy himself by solving questions and that he learned repeating the highlights strategy from his teacher. S4 was further determined to have developed the repeating the highlights strategy herself by solving questions and that he learned re-reading, reading other options for verification and underlining the clues meta-cognitive strategies from her teachers.

S5 who studied at the State Secondary School, who answered the Biology question wrong and achieved an "Average (AVE)" success level corresponding to the GPA in science was determined to have learned the re-reading and reviewing the graphics meta-cognitive strategies from her teachers and she learned marking the graphics strategy from her friends. S6, who was studying at the State Secondary School, who answered the question wrong (W) and achieved a

"Poor (P)" success level, was determined to have learned the re-reading strategy from her teacher whereas she learned reviewing the graph meta-cognitive strategy from her family members (mom, dad, sister and brother). S7, who was studying at the State Secondary School, who answered the question wrong (W) and achieved a "Poor (P)" success level, was determined to have learned the repeating the highlights strategy from her family members (mom, dad, sister and brother) whereas she learned reviewing the graph meta-cognitive strategy from her teachers. S8, who was studying at a State Secondary School, who answered the question wrong (W) and achieved a "Poor (P)" success level, was determined to have learned the re-reading and reviewing the graph meta-cognitive strategies from his family members (mom, dad, sister and brother).

4. Discussion

There are studies in the literature on the cognitive-meta cognitive strategies that students have employed while solving multiple-choice questions (Montague, 1992; Antonietti, Ignazi & Perego, 2000; Goos, Galbraith & Renshaw, 2000; Secil Ozkaya, 2000; Hammouri, 2003; Karatas & Guven, 2003; Victor, 2004; Yimer & Ellerton, 2005; Caliskan, Selcuk Sezgin & Erol, 2006; Karacam, 2009; Diken, 2014; Diken & Yuruk, 2019; Diken, 2020a; Diken; 2020b). Tutar, Demir & Diken, 2020). However, studies addressing the sources of these strategies are quite limited. Diken (2020b) conducted a research aiming to examine the sources of the cognitive and meta-cognitive strategies employed by 7th grade secondary school students while learning the "Cells and Divisions" unit of the 7th grade science course curriculum. At the end of this research, Diken (2020b) concluded that the sources of the cognitive strategies employed by students with high GPA while learning the unit were themselves, whereas the sources of the meta-cognitive strategies they used were their teachers and friends. The sources of the cognitive/meta-cognitive strategies employed by students with average and poor GPAs while learning the unit were solely the students themselves, whereas the students with the lowest (Fail) GPA were determined to have used no cognitive/meta-cognitive strategies while learning the unit.

5. Conclusions

The results obtained from the research indicated that the sources of the cognitive and meta-cognitive strategies employed by students whose 8th grade science course grade point averages were "Very Good" and who answered the questions correctly in the process of solving the questions were themselves. It was further determined that the sources of the cognitive and meta-cognitive strategies employed by students whose grade point averages were "Good" and who answered the questions correctly in the process of solving the questions were predominantly themselves and rarely their teachers. On the other hand the sources of the cognitive and meta-cognitive strategies employed by students whose grade point averages

were "Average" and who answered the questions wrong in the process of solving the questions were determined to be predominantly their teachers and friends and rarely themselves. The sources of the cognitive and meta-cognitive strategies employed by students whose grade point averages were "Poor" and "Very Low (Fail)" and who answered the questions wrong in the process of solving the questions were determined to be predominantly their teachers and their family members (mom, dad, sister, brother etc.).

In accordance with the results obtained from this research, we can conclude that teaching cognitive/meta-cognitive strategies to students with "Very Good" and "Good" GPAs may help to decrease the learning time of the strategies that students develop on their own while solving multiple-choice science questions. Another conclusion derived from the results of this research is that it may be more appropriate to teach cognitive/meta-cognitive strategies to the teachers of the students whose GPAs are "Average", "Poor" and "Very Low (Fail)" rather than teaching these strategies to the students themselves.

6. Recommendations

1. This research may further be applied to students at different grade levels of secondary schools (5th, 6th and 7th grades) and in the process of solving science questions from different units.

2. It is concluded that cognitive/meta-cognitive strategies that lead to find the correct answers to multiple-choice science questions should be taught directly to students with Very Good and Good grade point averages.

3. It is further concluded that cognitive/meta-cognitive strategies that lead to find the correct answers to multiple-choice science questions should be taught to the teachers of students with Average, Poor and Very Low (Fail) grade point averages.

4. Trainings on cognitive/meta-cognitive strategies that lead to find the correct answers to multiple-choice science questions to be provided to the science teachers will help these teachers to further teach to use these strategies correctly and appropriately, to students at different grade levels, particularly to students whose GPA level is "Average", "Poor", "Very Low (Fail)". At the end of such a practice, the chances of secondary school students being able to answer multiple choice questions correctly as expert problem solvers may be improved significantly.

Declaration of Conflicting Interests and Ethics

This research was conducted with the permission of Kafkas University Social and Human Sciences Scientific Research and Publication Ethics Board dated 27.12.2021 and numbered E-45241.

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