10.22633/rpge.v29iesp3.20699

Revista on line de Política e Gestão Educacional
Online Journal of Policy and Educational Management

THE IMPACT OF TEACHING PROBLEM-SOLVING STRATEGIES ON PRE-SERVICE SCIENCE TEACHERS' PERFORMANCE IN SOLVING MULTIPLE-CHOICE QUESTIONS

O IMPACTO DO ENSINO DE ESTRATÉGIAS DE RESOLUÇÃO DE PROBLEMAS NO DESEMPENHO DOS PROFESSORES DE CIÊNCIAS EM FORMAÇÃO NA RESOLUÇÃO DE QUESTÕES DE MÚLTIPLA ESCOLHA

EL IMPACTO DE LA ENSEÑANZA DE ESTRATEGIAS DE RESOLUCIÓN DE PROBLEMAS EN EL RENDIMIENTO DE LOS PROFESORES DE CIENCIAS EN FORMACIÓN EN LA RESOLUCIÓN DE PREGUNTAS DE OPCIÓN MÚLTIPLE

Emine Hatun DIKEN[1]
hatundiken06@gmail.com

[1] Kafkas University, Dedekorkut Faculty of Education, Kars, Turkey

How to reference this paper:

Diken, E. H. (2025). The impact of teaching problem-solving strategies on pre-service science teachers' performance in solving multiple-choice questions. *Revista online de Política e Gestão Educacional, 29*(esp3), e025080. https://doi.org/10.22633/rpge.v29iesp3.20699

Submitted: 02/09/2025
Revisions required: 10/09/2025
Approved: 17/09/2025
Published: 27/11/2025

ABSTRACT: This study investigates the effect of teaching problem-solving strategies on the performance of pre-service science teachers when answering multiple-choice questions. Adopting a qualitative case study design, the research involved six second-year pre-service teachers from the Department of Science Education at a university in Kars province. Data were collected using six multiple-choice questions from Physics, Chemistry, and Biology, along with a semi-structured interview form. Conducted over four weeks in the "Science Learning and Teaching Approaches" course, the study examined participants' strategies and accuracy before and after instruction in cognitive and metacognitive problem-solving methods. Content analysis revealed that, after receiving instruction, participants used a wider range of cognitive and metacognitive strategies more effectively. Additionally, a moderate improvement was observed in the number of correct responses. These results indicate that teaching problem-solving strategies positively influences pre-service teachers' performance on multiple-choice science questions.

KEYWORDS: Problem solving. Problem-solving strategies. Teaching of strategies. Cognitive strategy. Metacognitive strategy.

RESUMO: *Este estudo investiga o efeito do ensino de estratégias de resolução de problemas sobre o desempenho de professores de ciências em formação ao responder a questões de múltipla escolha. Adotando um desenho de estudo de caso qualitativo, a pesquisa envolveu seis professores do segundo ano do Departamento de Educação em Ciências de uma universidade na província de Kars. Os dados foram coletados por meio de seis questões de múltipla escolha de Física, Química e Biologia, juntamente com um formulário de entrevista semiestruturada. Conduzido ao longo de quatro semanas no curso "Abordagens de Aprendizagem e Ensino de Ciências", o estudo examinou as estratégias e a precisão dos participantes antes e depois da instrução em métodos cognitivos e metacognitivos de resolução de problemas. A análise de conteúdo revelou que, após receberem instruções, os participantes usaram uma gama mais ampla de estratégias cognitivas e metacognitivas de forma mais eficaz. Além disso, foi observada uma melhora moderada no número de respostas corretas. Esses resultados indicam que o ensino de estratégias de resolução de problemas influencia positivamente o desempenho dos professores em formação em questões de ciências de múltipla escolha.*

PALAVRAS-CHAVE: *Resolução de problemas. Estratégias de resolução de problemas. Ensino de estratégias. Estratégia cognitiva. Estratégia metacognitiva.*

RESUMEN: *Este estudio investiga el efecto de la enseñanza de estrategias de resolución de problemas sobre el rendimiento de los profesores de ciencias en formación al responder a preguntas de opción múltiple. Adoptando un diseño de estudio de caso cualitativo, la investigación involucró a seis profesores de segundo año del Departamento de Educación en Ciencias de una universidad en la provincia de Kars. Los datos se recopilaron mediante seis preguntas de opción múltiple de Física, Química y Biología, junto con un formulario de entrevista semiestructurada. Realizado a lo largo de cuatro semanas en el curso «Enfoques de aprendizaje y enseñanza de las ciencias», el estudio examinó las estrategias y la precisión de los participantes antes y después de la instrucción en métodos cognitivos y metacognitivos de resolución de problemas. El análisis del contenido reveló que, después de recibir instrucciones, los participantes utilizaron una gama más amplia de estrategias cognitivas y metacognitivas de manera más eficaz. Además, se observó una mejora moderada en el número de respuestas correctas. Estos resultados indican que la enseñanza de estrategias de resolución de problemas influye positivamente en el rendimiento de los profesores en formación en preguntas de ciencias de opción múltiple.*

PALABRAS CLAVE: *Resolución de problemas. Estrategias de resolución de problemas. Enseñanza de estrategias. Estrategia cognitiva. Estrategia metacognitiva.*

Article submitted to the similarity system

iThenticate

Editor: Prof. Dr. Sebastião de Souza Lemes
Deputy Executive Editor: Prof. Dr. José Anderson Santos Cruz

INTRODUCTION

Individuals need to have a set of skills to adapt to social change and life, and to grow up independently and successfully. Problem-solving, a teaching-learning method in educational sciences, comes to the fore to acquire these skills (Şahin, 2004). Before solving a problem, it is necessary to define the problem, which is a matter of thinking, discussion, and research, and is an uncertain and complex process (Van De Walle, 1989). A problem is an issue that motivates individuals to find a solution, for which there is no standard solution, and which can be solved by individuals using their knowledge and experience correctly (Türnüklü & Yeşildere, 2005). The effort to eliminate the uncertainties in a problem and to eliminate the difficulties encountered is called problem solving (Gelbal, 1991).

Problem solving involves students understanding a problem, designing a method to solve it, trying out different approaches to solve the problem, and deciding whether the solution is correct. Problem solving is the conscious exploration of a scientific topic to reach a goal that is clearly conceived but not immediately attainable. Problem solving is the process of confronting new situations and finding new and useful solutions by going beyond the simple applications of the rules learned through previous experiences to solve a problem (Gail, 1996; Korkut, 2002). In the problem-solving process, the accuracy of the result is important, but the solution path chosen, what the student visualizes in their mind while solving the problem, their understanding of the problem, and their use of strategies in solving the problem are also very important.

While solving problems, individuals use task and domain knowledge about the problem, components of the problem-solving process, and problem-solving strategies. In short, problem-solving strategies are one of the significant factors affecting students' problem-solving processes (Mayer, 1998). Since students exhibit cognitive and metacognitive behaviors while solving problems (Artzt & Armour Thomas, 1992), problem-solving strategies are divided into "cognitive strategies" and "metacognitive strategies" (Diken, 2020). Cognitive strategies are the tools and solutions that individuals use to carry out mental operations in problem-solving processes (Karaçam, 2009). Metacognitive strategies, on the other hand, are strategies used to evaluate whether cognitive strategies are working or not, to achieve cognitive goals, and to control these cognitive goals (Çakıroğlu, 2007; Hacker, 1998). While cognitive strategies only show individuals how to learn, metacognitive strategies provide individuals with the skills to learn how to learn.

Cognitive and metacognitive strategies are intertwined (Flavell, 1976). Therefore, a strategy can be both cognitive and metacognitive depending on the purpose of its use. The way to decide this is to look at the intended use of the strategy (Flavell, 1979; Livingstone, 1997). Some studies in the literature determine cognitive and metacognitive problem-solving strategies

(Antonietti et al., 2000; Ayres, 1993; Chi et al., 1981; Chi et al., 1989; de Jong & Ferguson-Hessler, 1986; Diken, 2014; Hammouri, 2003; Heyworth, 1999; Karaçam, 2009; Kramers Pals et al., 1983; Larkin et al., 1980; Owen & Sweller, 1985; Tutar et al., 2020). In addition to identifying cognitive and metacognitive problem-solving strategies, teaching these strategies to students is also crucial (Diken, 2020; Diken, 2024). For students to be successful in problem solving, it is necessary to teach them problem-solving strategies as well as subject knowledge (Arsal, 2009). Teachers should clearly explain to their students what problem-solving strategies do, when they should be used, how these strategies help solve problems, and guide their students on how to use strategies while solving problems (Hartman, 2001; Pressley & Gaskins, 2006).

In this study, cognitive and metacognitive problem-solving strategies were taught to pre-service science teachers. After the teaching of the strategies, the pre-service teachers' use of cognitive and metacognitive strategies in the process of solving the questions, and whether they answered the questions correctly, were examined. It is considered that teaching problem-solving strategies is crucial because it enhances pre-service teachers' problem-solving performance and encourages them to use a wide variety of cognitive and metacognitive strategies.

METHOD

Research Model

A case study, one of the qualitative research methods, was used in the study. A case study is a type of research that focuses on the questions "how" and "why," deeply examining and describing a phenomenon or event that the researcher cannot control (Merriam, 2009; Yıldırım & Şimşek, 2008).

Participants

Six pre-service teachers in the 2nd grade of the Department of Science Education of the Faculty of Education of a university in Kars province participated in the study. The real names of the pre-service teachers were kept confidential. The pre-service teachers are referred to as "P1, P2, P3, P4, P5, P6."

DATA COLLECTION TOOLS

Think Aloud Sessions with Multiple Choice Questions

The first data collection tool used in the study was the think-aloud sessions conducted during the solution processes of a total of six multiple-choice questions: two from the

Physics learning area, two from the Chemistry learning area, and two from the Biology learning area. The students were asked to solve three multiple-choice questions, one each from the learning areas of Physics, Chemistry, and Biology, before the teaching of the strategies, and three multiple-choice questions, one each from the learning areas of Physics, Chemistry, and Biology, after the teaching of the strategies. Multiple-choice questions have been selected from the KPSS-ÖABT (Public Personnel Selection Exam-Teacher Subject Knowledge Test) Science (Physics, Chemistry, Biology) Question Bank. Two questions from Physics are about "Force and Equilibrium", two questions from Chemistry are about "Periodic Table", and two questions from Biology are about "Nucleic Acids and Genetic Code".

The reason these topics were selected for the questions is that questions related to these topics are likely to be asked in the Public Personnel Selection Exam, which is held annually in Turkey and must be passed by teacher candidates to become teachers. The questions were re-checked by faculty members who are experts in the fields of Physics, Chemistry, and Biology. After checking the questions, the faculty members confirmed that there was no misinformation or misconception in the questions. Before and after the teaching of the strategies, the pre-service teachers were asked to solve multiple-choice questions in a think-aloud session. The think-aloud session is a technique that determines the relationship between individuals' problem-solving performance and other situations that are effective in problem solving (Van Someren et al., 1994, p. 11). In a think-aloud session, the individual is expected to verbally express their thoughts about the problem as they solve it (Newell & Simon, 1972).

In this study, to determine the strategies used by pre-service science teachers while solving multiple-choice questions and to distinguish these strategies as cognitive and metacognitive, pre-service science teachers were asked to solve multiple-choice questions aloud and to think aloud during their problem-solving process. Before the implementation of the study, the researcher made necessary explanations about the fact that thinking aloud means "verbalizing everything in the pre-service teachers' minds while solving multiple-choice questions." The pre-service teachers' processes of solving the questions with think-aloud sessions were recorded by the researcher.

Semi-Structured Interview Form

The second data collection tool used in the study is the semi-structured interview form. The interview form was developed by Diken (2014). The questions in the interview form were checked by two faculty members who have studied problem solving and cognitive and metacognitive strategies. After the faculty members checked the interview questions, they reaffirmed that these questions could be used in the study.

Semi-structured interviews were conducted with the pre-service teachers before and after the teaching of the strategies, after each problem they solved through think-aloud sessions. The aim of the semi-structured interviews with the pre-service teachers was to reaffirm the cognitive and metacognitive distinctions of the problem-solving strategies they used in solving multiple-choice questions.

The interview questions are as follows.

1) While solving the question, you did things like using formulas, underlining hints, etc. Why did you do these things?
2) What would you benefit from doing these (using formulas, underlining clues, etc.) while solving the question?
3) Are you sure the answer is correct?
4) What makes you sure that the answer is correct?

Implementation process of the study

The implementations of the study were carried out in four weeks in the "Science Learning and Teaching Approaches" course. The "Science Learning and Teaching Approaches" course is a two-hour course per week. Pre-service science teachers studying in the 2nd year of science teaching take this course. The faculty member who conducts the "Science Learning and Teaching Approaches" course is both a researcher and has studied cognitive and metacognitive strategies. The pre-service science teachers who voluntarily participated in the study had previously taken General Physics, General Chemistry, and General Biology courses, so they knew the learning areas of Physics, Chemistry, and Biology. During the first week of the implementation, in the "Science Learning and Teaching Approaches" course, pre-service teachers were asked to solve one multiple-choice question from the Physics learning area on the topic of 'Force and Balance,' one multiple-choice question from the Chemistry learning area on the topic of "Periodic Table," and one multiple-choice question from the Biology learning area on the topic of "Nucleic Acids and Genetic Code" with thinking aloud sessions accompanied by camera recordings.

Afterwards, semi-structured interviews were conducted with each pre-service teacher, again with camera recording. In the second week of the implementation, in the "Science Learning and Teaching Approaches" course, the researcher taught cognitive and metacognitive strategies to pre-service teachers. While teaching strategies, the researcher explained to the pre-service teachers, in order, what a strategy is, why it should be learned, its importance, and where, when, and how it can be used. The researcher distributed a list of strategies to the pre-service teachers, asked them to work on this list for

a week, and apply these strategies again to the multiple-choice questions they solved. In the third week of the implementation, in the "Science Learning and Teaching Approaches" course, the researcher asked the pre-service teachers to solve the questions they had solved in the first week by using the cognitive and metacognitive strategies taught in the second week of the implementation.

While the pre-service teachers were solving the questions, the researcher guided them to use the strategies. In the fourth week of the implementation, the researcher briefly reminded the cognitive and metacognitive strategies to the pre-service teachers in the "Science Learning and Teaching Approaches" course. The other three multiple-choice questions belonging to the subject of "Force and Balance" from the Physics learning area, "Periodic Table" from the Chemistry learning area, and "Nucleic Acids and Genetic Code" from the Biology learning area, which were different from the questions they had solved before the teaching of strategies, were solved by the pre-service teachers with thinking aloud sessions and camera recording. Afterwards, semi-structured interviews were conducted with each pre-service teacher, with camera recording. The implementation process of the study on teaching cognitive and metacognitive strategies has been completed in this manner.

Data Analysis

In the study, first, transcripts were made of the camera recordings of pre-service science teachers' processes of solving multiple-choice Physics, Chemistry, and Biology questions and of the semi-structured interviews conducted before and after the teaching of strategies. The transcripts were computerized and coded using software designed for qualitative research. In the qualitative data analysis software, first of all, two categories were created: "Before Teaching Strategies" and "After Teaching Strategies." "Cognitive Strategies" and "Metacognitive Strategies" themes were created under each of the "Before Teaching Strategies" and "After Teaching Strategies" categories. Observations of pre-service teachers thinking aloud while solving multiple-choice questions, along with their responses to semi-structured interview questions regarding the purpose behind each strategy used by each pre-service teacher, were coded as themes to the related strategies.

Codes were assigned to the themes of "Cognitive Strategies" and "Metacognitive Strategies" in the categories "Before Teaching Strategies" and "After Teaching Strategies," the strategies used by teacher candidates to arrive at the solutions to the questions were coded under the cognitive strategies theme, while the strategies used to monitor, control, or evaluate the question-solving processes were coded under the metacognitive strategies theme. To be sure of the data obtained from the coding, two faculty members who had sufficient knowledge about problem-solving and cognitive and metacognitive strategies

came together to discuss the reliability and consistency of the codes regarding whether the strategies were cognitive or metacognitive. After the coding was completed, one data set belonging to a pre-service teacher was also coded by two faculty members, who were the other coders. The consistency percentage between the codes provided by the coders was found to be 96%. On the inconsistent data sections, the coders worked together and reached a consensus.

FINDINGS

The tables below present the cognitive and metacognitive strategies used by teacher candidates when solving multiple-choice Physics, Chemistry, and Biology questions before and after the teaching of cognitive and metacognitive problem-solving strategies, along with their correct or incorrect responses to the questions. The relevant explanations are provided below each Table.

Table 1 shows the cognitive strategies used by pre-service teachers while solving multiple-choice Physics questions before and after the teaching of strategies.

Table 1
Cognitive strategies used by pre-service teachers before and after teaching strategies

1st MULTIPLE CHOICE PHYSICS QUESTION	
Cognitive strategies used before the teaching of strategies	**Pre-service teachers**
Examining the Figures	P1, P2, P3, P4, P5, P6
Reading starting from the root of the problem	P1, P2, P3, P4
Note-taking	P1, P2, P3, P4
Reading by following the words with a pen	P4, P5, P6
Reading with underlining words	P1, P2, P3
Reflecting the problem in behavior	P1,P3
Slowing down reading speed	P5, P6
2nd MULTIPLE CHOICE PHYSICS QUESTION	
Cognitive strategies used after the teaching of strategies	**Pre-service teachers**
Reading starting from the root of the problem	P1, P2, P3, P4, P5, P6
Trial and error	P1, P2, P3, P4, P5, P6
Compare shapes with each other	P1, P2, P3, P4, P5, P6
Note-taking	P1, P2, P3, P4, P5, P6
Option Elimination	P1, P2, P3, P4, P5, P6

10.22633/rpge.v29iesp3.20699

2nd MULTIPLE CHOICE PHYSICS QUESTION	
Cognitive strategies used after the teaching of strategies	**Pre-service teachers**
Visualization	P1, P2, P3, P4, P5
Establishing equations	P1, P2, P3, P4, P5
Reflect the result of the operation on the figure	P1, P2, P3, P4, P6
Expressing in own words	P1, P2, P4, P5
Using formulas	P1, P2, P3, P4
Numerical value giving	P1, P2, P3, P4
Part-by-part identification	P2, P3, P4, P6
Grouping	P1, P3, P5, P6
Reading with underlining words	P1, P2, P3

Note. Prepared by the author (2025).

As can be seen in Table 1, before the teaching of strategies, pre-service science teachers solved the first multiple-choice Physics question by using the following cognitive strategies: examining the figure (P1, P2, P3, P4, P5, P6), reading the question starting from the root (P1, P2, P3, P4), taking notes (P1, P2, P3, P4), reading while tracing the words with a pencil (P4, P5, P6), reading while underlining words (P1, P2, P3), reflecting the problem in their behavior (P1, P2, P3), and slowing down their reading speed (P5, P6). After teaching the strategies, while solving the second multiple-choice Physics question, pre-service teachers used the following cognitive strategies: reading from the root of the question (P1, P2, P3, P4, P5, P6), trial and error (P1, P2, P3, P4, P5, P6), comparing figures (P1, P2, P3, P4, P5, P6), taking notes (P1, P2, P3, P4, P5, P6), eliminating options (P1, P2, P3, P4, P5, P6), visualizing (P1, P2, P3, P4, P5), creating equations (P1, P2, P3, P4, P5), reflecting the result of the operation on the figure (P1, P2, P3, P4, P6), expressing in own words (P1, P2, P4, P5), using formulas (P1, P2, P3, P4), assigning numerical values (P1, P2, P3, P4), defining in parts (P2, P3, P4, P6), grouping (P1, P3, P5, P6), and reading while underlining words (P1, P2, P3).

Table 2 shows the metacognitive strategies used by pre-service teachers while solving multiple-choice Physics questions before and after the teaching of strategies.

As can be seen in Table 2, pre-service science teachers used the following metacognitive strategies when solving the first multiple-choice Physics question before the instruction of strategies: re-reading (P1, P2, P5, P6), note-taking (P1, P2, P3, P4), reflecting the problem on their behavior (P1, P2, P3), reading with underlining (P3, P5, P6), repeating important points (P1, P3), and asking themselves questions (P3, P5). After learning the strategies, pre-service teachers were observed to use re-reading (P1, P2, P3, P4, P5, P6), underlining clues

10.22633/rpge.v29iesp3.20699

(P1, P2, P3, P4, P5, P6), circling clues (P1, P2, P3, P4, P5, P6), re-examining the figure (P1, P2, P3, P4, P5, P6), asking themselves questions (P1, P2, P3, P4, P5, P6), checking the correctness of the option (P1, P2, P3, P4, P5, P6), checking the solution process (P1, P2, P3, P4, P5, P6), taking notes (P1, P2, P3, P4, P5, P6), repeating highlights (P3, P4, P5, P6), thinking about the steps in the solution process (P1, P2, P3, P4), and marking the shape (P1, P2, P3, P4) metacognitive strategies.

Table 2
Metacognitive strategies used by pre-service teachers before and after teaching strategies

1st MULTIPLE CHOICE PHYSICS QUESTION	
Metacognitive strategies used before the teaching of strategies	**Pre-service teachers**
Re-reading	P1, P2, P5, P6
Note-taking	P1, P2, P3, P4
Reflecting the problem in behavior	P1, P2, P3
Reading with underlining words	P3, P5, P6
Repeating highlights	P1, P3
Asking oneself questions	P3, P5
2nd MULTIPLE CHOICE PHYSICS QUESTION	
Metacognitive strategies used after the teaching of strategies	**Pre-service teachers**
Re-reading	P1, P2, P3, P4, P5, P6
Underlining clues	P1, P2, P3, P4, P5, P6
Encircling clues	P1, P2, P3, P4, P5, P6
Reviewing the Figure	P1, P2, P3, P4, P5, P6
Asking oneself questions	P1, P2, P3, P4, P5, P6
Checking the correctness of the selected option	P1, P2, P3, P4, P5, P6
Checking the solution process	P1, P2, P3, P4, P5, P6
Note-taking	P1, P2, P3, P4, P5
Repeating highlights	P3, P4, P5, P6
Thinking about the processes in the solution process	P1, P2, P3, P4
Put a mark on the shape	P1, P2, P3, P4

Note. Prepared by the author (2025).

The responses of the pre-service teachers to the Physics questions before and after the teaching of the strategies are shown in Table 3.

Table 3
Metacognitive strategies used by pre-service teachers before and after teaching strategies

1st MULTIPLE CHOICE PHYSICS QUESTION	
Answer given to the question before the teaching of the strategies	**Pre-service teachers**
Correct Answer	P1, P2
Wrong Answer	P3, P4, P5, P6
2nd MULTIPLE CHOICE PHYSICS QUESTION	
Answer given to the question after the teaching of the strategies	**Pre-service teachers**
Correct Answer	P1, P2, P3
Wrong Answer	P4, P5, P6

Note. Prepared by the author (2025).

As can be seen in Table 3, before the teaching of strategies, two pre-service teachers (P1, P2) answered the first multiple-choice Physics question correctly, while four pre-service teachers (P3, P4, P5, P6) answered incorrectly. Following the teaching of strategies, three pre--service teachers (P1, P2, P3) answered the second Physics question correctly, while three pre--service teachers (P4, P5, P6) answered it incorrectly.

Table 4 shows the cognitive strategies used by pre-service teachers while solving multiple-choice Chemistry questions before and after the teaching of strategies.

As can be seen in Table 4, it was determined that the pre-service science teachers used the following cognitive strategies while solving the first multiple-choice Chemistry question before the teaching of strategies: examining the table (P1, P2, P3, P4, P5, P6), reading starting from the root of the question (P1, P2, P3, P4), note-taking (P1, P2, P3, P4), reading while tracing the words with a pen (P4, P5, P6), and fraction simplification/expansion (P1, P2).

After teaching the strategies, pre-service teachers used the following cognitive strategies while solving the second multiple-choice Chemistry question: read the question starting from the root (P1, P2, P3, P4, P5, P6), trial and error (P1, P2, P3, P4, P5, P6), comparing explanations with tables (P1, P2, P3, P4, P5, P6), note-taking (P1, P2, P3, P4, P5, P6), eliminating options (P1, P2, P3, P4, P5, P6), expressing in own words (P1, P2, P4, P5), establishing proportions (P1, P2, P3, P4), using formulas (P1, P2, P3, P4), simplifying/expanding fractions (P1, P2, P4, P5), reading by underlining words (P1, P2, P3), and reflecting the result of the operation on the table (P1, P3, P4).

Table 4
Cognitive strategies used by pre-service teachers before and after teaching strategies

1st MULTIPLE CHOICE CHEMISTRY QUESTION	
Cognitive strategies used before the teaching of strategies	**Pre-service teachers**
Examining the Tables	P1, P2, P3, P4, P5, P6
Reading starting from the root of the problem	P1, P2, P3, P4
Note-taking	P1, P2, P3, P4
Reading by following the words with a pen	P4, P5, P6
Fraction simplification/expansion	P1, P2
2nd MULTIPLE CHOICE CHEMISTRY QUESTION	
Cognitive strategies used after the teaching of strategies	**Pre-service teachers**
Reading starting from the root of the problem	P1, P2, P3, P4, P5, P6
Trial and error	P1, P2, P3, P4, P5, P6
Compare table and comments	P1, P2, P3, P4, P5, P6
Note-taking	P1, P2, P3, P4, P5, P6
Option Elimination	P1, P2, P3, P4, P5, P6
Expressing in own words	P1, P2, P4, P5
Proportioning	P1, P2, P3, P4
Using formulas	P1, P2, P3, P4
Fraction simplification/expansion	P1, P2, P4, P5
Reading with underlining words	P1, P2, P3
Reflect the result of the operation on the table	P1, P3, P4

Note. Prepared by the author (2025).

Table 5 shows the metacognitive strategies used by pre-service teachers while solving multiple-choice Chemistry questions before and after the teaching of strategies.

Table 5
Metacognitive strategies used by pre-service teachers before and after teaching strategies

1st MULTIPLE CHOICE CHEMISTRY QUESTION	
Metacognitive strategies used before the teaching of strategies	**Pre-service teachers**
Re-reading	P1, P2, P5, P6
Note-taking	P1, P2, P3, P4
Reviewing the Table	P1, P2, P3
Reading with underlining words	P3, P5, P6
Repeating highlights	P1, P3

2nd MULTIPLE CHOICE CHEMISTRY QUESTION	
Metacognitive strategies used after the teaching of strategies	Pre-service teachers
Re-reading	P1, P2, P3, P4, P5, P6
Underlining clues	P1, P2, P3, P4, P5, P6
Encircling clues	P1, P2, P3, P4, P5, P6
Reviewing the Table	P1, P2, P3, P4, P5, P6
Checking the correctness of the selected option	P1, P2, P3, P4, P5, P6
Checking the solution process	P1, P2, P3, P4, P5, P6
Backtracking	P1, P2, P3, P4, P5, P6
Note-taking	P1, P2, P3, P4, P5
Repeating highlights	P3, P4, P5, P6
Put a mark on the Table	P1, P2, P3, P4

Note. Prepared by the author (2025).

As can be seen in Table 5, before the teaching of strategies, pre-service science teachers used the following metacognitive strategies while solving the first multiple-choice Chemistry question: rereading (P1, P2, P5, P6), note-taking (P1, P2, P3, P4), re-examining the table (P1, P2, P3), reading while underlining words (P3, P5, P6), and repeating highlights (P1, P3).

After teaching the strategies, pre-service teachers used the following metacognitive strategies while solving the second multiple-choice Chemistry question: re-reading (P1, P2, P3, P4, P5, P6), underlining clues (P1, P2, P3, P4, P5, P6), circling clues (P1, P2, P3, P4, P5, P6), re-examining the table (P1, P2, P3, P4, P5, P6), checking the correctness of the option (P1, P2, P3, P4, P5, P6), checking the solution process (P1, P2, P3, P4, P5, P6), backtracking (P1, P2, P3, P4, P5, P6), note-taking (P1, P2, P3, P4, P5), repeating highlights (P3, P4, P5, P6), and marking the table (P1, P2, P3, P4).

Table 6 shows the responses of the pre-service teachers to the Chemistry questions before and after the teaching of the strategies.

Table 6
Pre-service teachers' responses to the Chemistry questions before and after the teaching of strategies

1st MULTIPLE CHOICE CHEMISTRY QUESTION	
Answer given to the question before the teaching of the strategies	**Pre-service teachers**
Correct Answer	P1, P2, P3
Wrong Answer	P4, P5, P6

10.22633/rpge.v29iesp3.20699

2nd MULTIPLE CHOICE CHEMISTRY QUESTION	
Answer given to the question after the teaching of the strategies	**Pre-service teachers**
Correct Answer	P1, P2, P3, P4
Wrong Answer	P5, P6

Note. Prepared by the author (2025).

As can be seen in Table 6, before the teaching of strategies, three pre-service teachers (P1, P2, P3) answered the first multiple-choice Chemistry question correctly, while three pre-service teachers (P4, P5, P6) answered the first Chemistry question incorrectly. Following the teaching of strategies, four pre-service teachers (P1, P2, P3, P4) answered the second Chemistry question correctly, while three pre-service teachers (P5, P6) answered it incorrectly.

Table 7 shows the cognitive strategies used by pre-service teachers while solving multiple-choice Biology questions before and after the teaching of strategies.

Table 7
Cognitive strategies used by pre-service teachers before and after teaching strategies

1st MULTIPLE CHOICE BIOLOGY QUESTION	
Cognitive strategies used before the teaching of strategies	**Pre-service teachers**
Examining the Figures	P1, P2, P3, P4, P5, P6
Reading starting from the root of the problem	P1, P2, P3, P4
Reading with underlining words	P1, P2, P3, P4
Reading by following the words with a pen	P4, P5, P6
Slowing down reading speed	P5, P6
2nd MULTIPLE CHOICE BIOLOGY QUESTION	
Cognitive strategies used after the teaching of strategies	**Pre-service teachers**
Reading starting from the root of the problem	P1, P2, P3, P4, P5, P6
Compare Figure and descriptions	P1, P2, P3, P4, P5, P6
Compare descriptions with each other	P1, P2, P3, P4, P5, P6
Note-taking	P1, P2, P3, P4, P5, P6
Trial and error	P1, P2, P3, P4, P5, P6
Option Elimination	P1, P2, P3, P4, P5, P6
Associating what is given in the question with daily life	P1, P2, P3, P4, P5
Visualization	P1, P2, P3, P4
Expressing in own words	P1, P2, P4, P5

Note. Prepared by the author (2025).

As can be seen in Table 7, before the teaching of strategies, pre-service science teachers used the following cognitive strategies while solving the first multiple-choice Biology question: examining the figure (P1, P2, P3, P4, P5, P6), starting from the root of the question (P1, P2, P3, P4), reading while underlining words (P1, P2, P3, P4), reading while tracing words with a pen (P4, P5, P6), and slowing down reading speed (P5, P6).

After teaching the strategies, pre-service teachers used the following cognitive strategies while solving the second multiple-choice Biology question starting from the root of the question (P1, P2, P3, P4, P5, P6), comparing the explanations with the figure (P1, P2, P3, P4, P5, P6), comparing the explanations with each other (P1, P2, P3, P4, P5, P6), note taking (P1, P2, P3, P4, P5, P6), trial and error (P1, P2, P3, P4, P5, P6), eliminating options (P1, P2, P3, P4, P5, P6), relating the information given in the question to daily life (P1, P2, P3, P4, P5), visualization (P1, P2, P3, P4), and expressing in own words (P1, P2, P4, P5).

Table 8 shows the metacognitive strategies used by pre-service teachers while solving multiple-choice Biology questions before and after the teaching of strategies.

Table 8
Metacognitive strategies used by pre-service teachers before and after teaching strategies

1st MULTIPLE CHOICE BIOLOGY QUESTION	
Metacognitive strategies used before the teaching of strategies	**Pre-service teachers**
Re-reading	P1, P2, P5, P6
Note-taking	P1, P2, P3, P4
Reading with underlining words	P3, P5, P6
Repeating highlights	P1, P3
Asking oneself questions	P3, P5
2nd MULTIPLE CHOICE BIOLOGY QUESTION	
Metacognitive strategies used after teaching of strategies	**Pre-service teachers**
Re-reading	P1, P2, P3, P4, P5, P6
Thinking about the processes in the solution process	P1, P2, P3, P4, P5, P6
Underlining clues	P1, P2, P3, P4, P5, P6
Encircling clues	P1, P2, P3, P4, P5, P6
Reviewing the Figure	P1, P2, P3, P4, P5, P6
Asking oneself questions	P1, P2, P3, P4, P5, P6
Checking the correctness of the selected option	P1, P2, P3, P4, P5, P6
Checking the solution process	P1, P2, P3, P4, P5, P6
Note-taking	P1, P2, P3, P4, P5
Repeating highlights	P1, P2, P3, P4
Put a mark on the shape	P1, P2, P3, P4

Note. Prepared by the author (2025).

As can be seen in Table 8, before the teaching of strategies, pre-service science teachers used the following metacognitive strategies while solving the first multiple-choice Biology question: rereading (P1, P2, P5, P6), note-taking (P1, P2, P3, P4), reading while underlining words (P3, P5, P6), repeating highlights (P1, P3), and asking questions to oneself (P3, P5).

After teaching the strategies, pre-service teachers used the following strategies while solving the second multiple-choice Biology question: re-reading (P1, P2, P3, P4, P5, P6), thinking about the steps in the solution process (P1, P2, P3, P4, P5, P6), underlining clues (P1, P2, P3, P4, P5, P6), circling clues (P1, P2, P3, P4, P5, P6), re-examining the figure (P1, P2, P3, P4, P5, P6), asking oneself questions (P1, P2, P3, P4, P5, P6), checking the correctness of the option (P1, P2, P3, P4, P5, P6), checking the solution process (P1, P2, P3, P4, P5, P6), note-taking (P1, P2, P3, P4, P5), repeating highlights (P1, P2, P3, P4), and marking the figure (P1, P2, P3, P4).

Table 9 shows the responses of the pre-service teachers to the Biology questions before and after the teaching of the strategies.

Table 9
Pre-service teachers' responses to the Chemistry questions before and after the teaching of strategies

1st MULTIPLE CHOICE BIOLOGY QUESTION	
Answer given to the question before the teaching of the strategies	**Pre-service teachers**
Correct Answer	P1, P2, P3,
Wrong Answer	P4, P5, P6
2nd MULTIPLE CHOICE BIOLOGY QUESTION	
Answer given to the question after the teaching of the strategies	**Pre-service teachers**
Correct Answer	P1, P2, P3, P4, P5
Wrong Answer	P6

Note. Prepared by the author (2025).

As can be seen in Table 9, before the teaching of strategies, three pre-service teachers (P1, P2, P3) answered the first multiple-choice Biology question correctly, while three pre-service teachers (P4, P5, P6) answered the first Biology question incorrectly. Following the teaching of strategies, five pre-service teachers (P1, P2, P3, P4, P5) answered the second Biology question correctly, while one pre-service teacher (P6) answered it incorrectly.

CONCLUSION AND DISCUSSION

After teaching cognitive and metacognitive problem-solving strategies, while solving multiple-choice Physics questions pre-service science teachers mostly used cognitive strategies

such as starting from the root of the problem, trial and error, comparing shapes, note-taking, eliminating options, visualization, formulating equations, reflecting the result of the operation on the figure, and metacognitive strategies such as re-reading, underlining clues, circling clues, re-examining the figure, asking oneself questions, checking the correctness of the option, and checking the solution process.

After teaching the strategies, while solving multiple-choice Chemistry questions, pre-service science teachers mostly used cognitive strategies such as reading from the root of the question, trial and error, comparing explanations with tables, note-taking, eliminating options, expressing in their own words, establishing proportions, using formulas, and simplifying/expanding fractions. They were also found to employ metacognitive strategies, such as re-reading, underlining clues, circling key points, re-examining the table, verifying the correctness of the options, reviewing the solution process, backtracking, and taking notes.

After the teaching of strategies, while solving multiple-choice Biology questions, pre-service science teachers mostly used cognitive strategies such as starting from the root of the question, comparing explanations with figures, comparing explanations with each other, note-taking, trial and error, eliminating options, and relating the information in the question to daily life. They were also found to use metacognitive strategies such as re-reading, thinking about the steps in the solution process, underlining clues, circling clues, re-examining the diagram, asking oneself questions, checking the correctness of the option, and checking the solution process. There are some studies in the literature that determine the cognitive and metacognitive problem-solving strategies identified after the teaching of strategies (Anastasiou & Griva, 2009; Diken, 2014; Diken & Yürük, 2019; Diken, 2020; Diken, 2024; Goos et al., 2006; Karaçam, 2009; Montague, 1992; O'Malley & Chamot, 1990; Tutar et al., 2020; Weir, 1999).

A noteworthy finding of the study is that after learning problem-solving strategies, pre-service teachers employed a greater number and variety of cognitive and metacognitive strategies when solving multiple-choice questions compared to the strategies they used before learning these strategies. Previous studies have found that teaching problem-solving strategies increases students' use of strategies (Altun & Arslan, 2006).

Before the teaching of cognitive and metacognitive problem-solving strategies, two pre-service teachers answered the Physics question correctly, three pre-service teachers answered the Chemistry question correctly, and four pre-service teachers answered the Biology question correctly. After teaching the strategies, three pre-service teachers answered the Physics question correctly, four pre-service teachers answered the Chemistry question correctly, and five pre-service teachers answered the Biology question correctly. Some studies have determined that teaching problem-solving strategies has a positive effect on students' achievement (Altun & Arslan, 2006; Arsuk & Sezgin Memnun, 2020; Chang & Lederman, 1994; Gök & Sılay, 2008; Heller et al., 1992; Hollabaugh, 1995; Leonard et al., 1996; Yazgan, 2007; Yıldızlar, 2023).

In the study, it was observed that the number of pre-service teachers who answered each question correctly increased by one after the teaching of the strategies. In other words, there was a small increase in the number of pre-service teachers who answered the questions correctly after the strategies were taught. The use of a large number and variety of cognitive and metacognitive strategies by pre-service teachers when solving multiple-choice questions is not sufficient on its own to ensure that the questions are answered correctly. The pre-service teachers' high level of knowledge in Physics, Chemistry, and Biology, and the absence of misconceptions about the subjects to which the questions belong, are also necessary for them to answer the questions correctly.

Therefore, it can be stated that the strategies used by pre-service teachers while solving the questions are a tool in answering the questions correctly. In the results of their studies, Diken (2014), Diken (2020), Diken (2024), Tutar et al. (2020) found that cognitive and metacognitive strategies are a tool for students to reach the correct answers of multiple-choice questions.

Based on the results obtained from the study, the following recommendations can be made.

1) Cognitive and metacognitive problem-solving strategies can be taught to middle and high school students.
2) In addition to multiple-choice questions, students can be taught cognitive and metacognitive problem-solving strategies for science texts with open-ended science questions.
3) Studies can be conducted that relate students' subject knowledge and conceptual misconceptions to their use of strategies in terms of number and variety as a result of teaching cognitive and metacognitive strategies.

REFERENCES

Altun, M., & Arslan, Ç. (2006). A study on primary school students' learning of problem-solving strategies. *Uludağ University Faculty of Education Journal, 19*(1), 1–21. https://dergipark.org.tr/en/download/article-file/153279

Anastasiou, D., & Griva, E. (2009). Awareness of reading strategy use and reading comprehension among poor and good readers. E*lementary Education Online, 8*(2), 283–297. https://dergipark.org.tr/en/download/article-file/90854

Antonietti, A., Ignazi, S., & Perego, P. (2000). Metacognitive knowledge about problem-solving methods. B*ritish Journal of Educational Psychology, 70(*1), 1–16. https://doi.org/10.1348/000709900157921

Arsal, Z. (2009). The predictive power of problem-solving strategies on problem-solving success. *Abant İzzet Baysal University Faculty of Education Journal, 9*(1), 103–113. https://dergipark.org.tr/tr/download/article-file/16667

Arsuk, S., & Sezgin Memnun, D. (2020). The effect of the teaching of problem-solving strategies supported by metacognitive strategies on problem-solving success and metacognitive skills of seventh grade students. *Muş Alpaslan University Anemon Social Sciences Journal, 8*(2), 559–573. https://doi.org/10.18506/anemon.634989

Artzt, A. F., & Armour-Thomas, E. (1992). Development of a cognitive-metacognitive framework for protocol analysis of mathematical problem solving in small groups. *Cognition and Instruction, 9*(2), 137–175. https://doi.org/10.1207/s1532690xci0902_3

Ayres, P. L. (1993). Why goal-free problems can facilitate learning. *Contemporary Educational Psychology, 18*(3), 376–381. https://doi.org/10.1006/ceps.1993.1027

Çakıroğlu, A. (2007). *The effect of metacognitive strategy training on improving the achievement level of students having low achievement levels of reading comprehension* [Ph.D. thesis]. Gazi University.

Chang, H. P., & Lederman, N. G. (1994). The effects of levels of cooperation within physical laboratory groups on physical science achievement. *Journal of Research in Science Teaching, 31*(2), 167–181. https://doi.org/10.1002/tea.3660310207

Chi, M. T. H., Bassok, M., Lewis, M. W., Reimann, P., & Glaser, R. (1989). Self-explanations: How students study and use examples in learning to solve problems. *Cognitive Science, 13*(2), 145–182. https://doi.org/10.1016/0364-0213(89)90002-5

Chi, M. T. H., Feltovich, P. J., & Glaser, R. (1981). Categorization and representation of physics problems by experts and novices. *Cognitive Science, 5*(2), 121–152. https://doi.org/10.1207/s15516709cog0502_2

Commission. (2021). *KPSS-ÖABT-2021 science question bank* (9th ed.). Pegem Academy. https://depo.pegem.net/9780202100302.pdf

De Jong, T., & Ferguson-Hessler, M. G. (1986). Cognitive structures of good and poor novice problem solvers in physics. *Journal of Educational Psychology, 78*(4), 279–288. https://doi.org/10.1037/0022-0663.78.4.279

Diken, E. H. (2014). *Determining the cognitive and metacognitive strategies used by 9th grade students in the solution process of multiple choice questions in the field of science* [Ph.D. thesis]. Gazi University.

Diken, E. H. (2020). Cognitive and metacognitive strategies of 6th-grade students to answer multiple-choice questions on "human body systems." I*nternational Journal of Curriculum and Instruction, 12(*2), 436–456. https://www.ijci.net/index.php/IJCI/article/view/435/202

Diken, E. H. (2024). Analyzing strategies employed by 7th grade students in correctly and incorrectly answering multiple-choice questions on "reproduction, growth, and development in living things." *International Online Journal of Education and Teaching, 11*(2), 506–524. https://iojet.org/index.php/IOJET/article/view/2103

Diken, E. H., & Yürük, N. (2019). Determining the cognitive and metacognitive strategies used by 9th grade students before, during, and after solving multiple choice questions in science. *Journal of Human and Social Sciences Research, 8(*2), 1071–1099. https://doi.org/10.15869/itobiad.512341

Flavell, J. H. (1976). Metacognitive aspects of problem solving. In L. B. Resnick (Ed.), *The nature of intelligence* (pp. 231–235). Lawrence Erlbaum.

Flavell, J. H. (1979). Metacognition and cognitive monitoring: A new area of cognitive–developmental inquiry. *American Psychologist, 34*(10), 906–911. https://doi.org/10.1037/0003-066X.34.10.906

Gail, M. (1996, June). Problem solving about problem solving: Framing a research agenda. In *Proceedings of the Annual National Educational Computing Conference*.

Gelbal, S. (1991). Problem solving. *Hacettepe University Faculty of Education Journal, 6*, 167–173. https://dergipark.org.tr/tr/download/article-file/88347

Gök, T., & Sılay, İ. (2008). The effects of problem-solving strategies on students' achievement, on the cooperative learning groups in physics teaching. *Hacettepe University Faculty of Education Journal, 34*, 116–126. https://dergipark.org.tr/en/download/article-file/87546

Goos, M., Galbraith, P., & Renshaw, P. (2000). A money problem: A source of insight into problem solving action. *International Journal for Mathematics Teaching and Learning, 13*, 1–21. https://www.cimt.org.uk/journal/pgmoney.pdf

Hacker, D. J. (1998). Definitions and empirical foundations. In D. J. Hacker, J. Dunlosky, & A. C. Graesser (Eds.), *Metacognition in educational theory and practice* (pp. 1–23). Lawrence Erlbaum Associates.

Hammouri, H. A. M. (2003). An investigation of undergraduates' transformational problem solving strategies: Cognitive/metacognitive processes as predictors of holistic/analytic strategies. *Assessment and Evaluation in Higher Education, 28*(6), 571–586. https://doi.org/10.1080/0260293032000130225

Hartman, H. J. (2001). Developing students' metacognitive knowledge and skills. In H. J. Hartman (Ed.), *Metacognition in learning and instruction* (pp. 33–68). Springer. https://doi.org/10.1007/978-94-017-2243-8_3

Heller, P., Keith, R., & Anderson, S. (1992). Teaching problem solving through cooperative grouping: Part I. Group versus individual problem solving. A*merican Journal of Physics, 60*(7), 627–636. https://doi.org/10.1119/1.17117

Heyworth, R. M. (1999). Procedural and conceptual knowledge of expert and novice students for the solving of a basic problem in chemistry. *International Journal of Science Education, 21*(2), 195–211. https://doi.org/10.1080/095006999290787

Kapa, E., & Gimbert, B. (2011). The relationship between metacognition and performance on similar and novel science problems. *Journal of Research in Science Teaching, 48(*4), 389–408. https://doi.org/10.1002/tea.20406

Kuhn, D. (2000). Metacognitive development. *Current Directions in Psychological Science, 9*(5), 178–181. https://doi.org/10.1111/1467-8721.00088

Kuhn, D., & Dean, D. (2004). Metacognition: A bridge between cognitive psychology and educational practice. *Theory Into Practice, 43*(4), 268–273. https://doi.org/10.1207/s15430421tip4304_4

Lee, H. S., & Kim, Y. (2014). Relationships between Korean students' problem-solving ability, cognitive strategy, and metacognitive strategy in science. *International Journal of Science Education, 36*(4), 635–661. https://doi.org/10.1080/09500693.2013.857361

Lin, X. (2001). Designing metacognitive activities. *Educational Technology Research and Development, 49*(2), 23–40. https://doi.org/10.1007/BF02504926

Livingston, J. A. (1997). *Metacognition: An overview.* State University of New York at Buffalo. https://eric.ed.gov/?id=ED474273

Mayer, R. E. (1992). *Thinking, problem solving, cognition* (2nd ed.). W. H. Freeman.

Memnun, D. S., & Akkaya, R. (2009). An investigation of seventh grade students' strategies in solving mathematical problems. *Elementary Education Online, 8*(1), 143–159. https://dergipark.org.tr/en/download/article-file/90826

Mokhtari, K., & Reichard, C. A. (2002). Assessing students' metacognitive awareness of reading strategies. *Journal of Educational Psychology, 94*(2), 249–259. https://doi.org/10.1037/0022-0663.94.2.249

Nokes, T. J., Hausmann, R. G., VanLehn, K., & Gershman, S. (2011). Testing the instructional fit hypothesis: The case of self-explanation and direct instruction. *Instructional Science, 39*(4), 645–666. https://doi.org/10.1007/s11251-010-9151-2

Oğuz, A. (2008). *The relationship between self-regulation strategies and motivational beliefs of prospective teachers* (Thesis No. 220958) [Ph.D. thesis, Gazi University].

Özsoy, G., & Ataman, A. (2009). The effect of metacognitive strategy training on problem solving achievement. *Elementary Education Online, 8*(1), 199–213. https://dergipark.org.tr/en/download/article-file/90831

Polya, G. (1957). *How to solve it: A new aspect of mathematical method*. Princeton University Press.

Pressley, M., Borkowski, J. G., & Schneider, W. (1987). Cognitive strategies: Good strategy users coordinate metacognition and knowledge. *Annals of Child Development, 4,* 80–129.

Schoenfeld, A. H. (1985). *Mathematical problem solving*. Academic Press.

Schoenfeld, A. H. (1992). Learning to think mathematically: Problem solving, metacognition, and sense making in mathematics. In D. Grouws (Ed.), *Handbook of research on mathematics teaching and learning* (pp. 334–370). Macmillan.

Schoenfeld, A. H. (2016). Learning to think mathematically: Problem solving, metacognition, and sense making in mathematics revisited. *ZDM Mathematics Education, 48*, 341–361. https://doi.org/10.1007/s11858-016-0794-8

Schraw, G., & Dennison, R. S. (1994). Assessing metacognitive awareness. *Contemporary Educational Psychology, 19*(4), 460–475. https://doi.org/10.1006/ceps.1994.1033

Senemoğlu, N. (2009). *Development, learning and teaching: From theory to practice*. Gazi Bookstore.

Sönmez, V. (2007). *Teaching principles and methods*. Anı Publishing.

Swanson, H. L. (1990). Influence of metacognitive knowledge and aptitude on problem solving. *Journal of Educational Psychology, 82*(2), 306–314. https://doi.org/10.1037/0022-0663.82.2.306

Tüysüz, C. (2013). The effect of problem solving strategies on academic achievement and metacognitive awareness of prospective science teachers. *Journal of Educational Sciences Research, 3*(1), 43–59. https://dergipark.org.tr/en/download/article-file/77338

Ulu, M. (2017). The relationship between prospective mathematics teachers' problem solving skills and their metacognitive awareness. *International Journal of Research in Education and Science, 3*(2), 560–570. https://www.ijres.net/index.php/ijres/article/view/223

Üredi, I., & Üredi, L. (2005). The effect of perceived problem solving skills and locus of control on academic achievement. *Mersin University Faculty of Education Journal, 1*(2), 219–228. https://dergipark.org.tr/en/download/article-file/161146

Veenman, M. V. J., Van Hout-Wolters, B. H. A. M., & Afflerbach, P. (2006). Metacognition and learning: Conceptual and methodological considerations. *Metacognition and Learning, 1*(1), 3–14. https://doi.org/10.1007/s11409-006-6893-0

Yıldızlar, M. (2015). *The effect of problem-based learning approach on students' metacognitive awareness and problem solving skills in science course* [Master's thesis]. Balıkesir University.

CRediT Author Statement

Acknowledgements: No.
Funding: This research did not receive any financial support.
Conflicts of interest: There is no conflict of interest.
Ethical approval: The work respected ethics during the research.
Data and material availability: The data and materials used in the work are not publicly available for access.
Authors' contributions: The author contributed entirely to the work.

Processing and editing: Editora Ibero-Americana de Educação
Proofreading, formatting, normalisation and translation