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The Effects of Formative Assessment Practices in Science Education on Students' Metacognitive Knowledge and Regulation Skills*

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ABSTRACT

This study aims to examine the effect of formative assessment practices performed in the science course on seventh-grade students' metacognitive knowledge and metacognitive regulation skills. This study is based on an embedded design. In the quantitative part of the study, the experimental-placebo-control group, pre-test, and post-test quasi-experimental design was used, and in the qualitative part the case study design was conducted. The study group of the quasi-experimental design was the seventh-grade students studying in three different classes of a public elementary school. Three different classes with similar characteristics were randomly identified as the experimental, control, and placebo groups. The study group of the quasi-experimental design consisted of 37 students in total, 12 students in the experimental and placebo groups, and 13 students in the control group. The study group of the case study consisted of 12 students. Interviews were conducted with these 12 students before and after the experimental process. In the study, while quantitative data were obtained through "Metacognitive Awareness Scale for Children", qualitative data were collected through the interview form prepared by the researchers. Kruskal-Wallis Test and Mann-Whitney U Test were used in the analysis of the quantitative data. Qualitative data were analyzed by descriptive analysis and categorical content analysis techniques. As a result of the study, it was determined that formative assessment practices had positive effects on students' metacognitive knowledge and metacognitive skills.

Keywords: Formative assessment, metacognition, middle school, science course

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1. INTRODUCTION

Assessment is an integral part of the teaching process (Linn, 1990), and influences many affective and cognitive characteristics of students. In this context, it has a great impact on students' several motivational features such as learning approaches (Struyven, Dochy & Janssens, 2005), motivation (Maslovaty & Kuzi, 2002), and achievement goal orientations (Ames, 1992; Buldur & Doğan, 2017; Brookhart, 1997) besides academic success (Bayrak, Çalık & Doğan, 2021; Black & William, 1998). One of these features is students' metacognitive awareness. The student's active participation in the assessment is essential for the development of their metacognitive awareness (Hattie & Timperley, 2007; Jones, 2007). In this regard, it is emphasized that formative assessment in which the students actively participate and is embedded throughout the teaching process, is quite important for the development of students' metacognitive awareness (Keeley, 2008). Based on the results obtained from the theoretical explanations and relevant studies on this subject, the relationship between the assessment practices carried out by the teachers in their classes and the metacognitive skills of the students was examined experimentally in this study.

1.1. Assessment and Types of Assessment

Assessment, which is performed throughout and at the end of the teaching process, has a fundamental role in testing the effectiveness of teaching plans, methods, and techniques used in the process, as well as determining the learning disabilities of the students and identifying the unachieved objectives (Baysal & Demirbaş, 2012). Different assessment approaches have been

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determined for these purposes. Considering the classifications, it is seen that assessment types are in the most general sense divided into four groups according to the purpose, the criteria, format, and nature of the assessment (Miller, Linn, & Gronlund, 2009). In this direction, the assessment types are classified as diagnostic, summative, and formative in terms of the purpose. In recent years, formative assessment has gained importance as it contributes more to the student, integrating the assessment into the whole learning and teaching process, as well as allowing for feedback and corrections, thereby becoming more suitable for the principles of contemporary learning theories. Accordingly, formative assessment is an approach that spans the entire learning process, in which students take an active role and activate their intrinsic motivation (Buldur, 2014).

Another type of assessment is associated with its format. This type of assessment is divided into two categories as traditional and alternative (performance-based). The traditional assessment seeks whether the students reach the predetermined goals in a certain period of time (Shepard, 1989). Since it is often emphasized that traditional methods and techniques fail to assess the characteristics of individuals (Çakıcı, 2008), it has become inevitable to shift to alternative assessment methods that also take the learning process into account rather than the traditional approach that only focuses on the product. The alternative assessment approaches are the approaches in which the developmental process of students is revealed and high-level thinking skills are assessed, thereby the assessment is spread throughout the learning process (Çepni & Ayvacı, 2007). On the other hand, another significant advantage of alternative assessment is that it provides the students with a chance to create their own learning schemes in the learning process. Moreover, the individuals who are active in their own learning process have the opportunity to develop their attitudes and values besides high-level thinking skills, as they act by knowing how they learn (Black & William, 1998; Durmuş, 2013; Hudesman et al., 2013; Taşkın & Çakmak, 2017; Wang, 2015). In this regard, metacognitive skills can be considered as one of the most important of these skills (Hattie & Timperley, 2007; Jones, 2007).

1.2. Metacognition

As a result of the recent changes in the teaching process, the ways of learning knowledge have become a matter of curiosity rather than the knowledge that is learned. The actual challenge in the new century is not related to what the individuals have already learned, but whether they know the ways of 'learning to learn' since the main reason for misknowledge is that the individual fails to know how to learn. Instead of listing what they will learn, a good teaching strategy should be organized in order to teach the individual how to learn, remember and be effective and responsible in their own learning (Çakıroğlu, 2007). The most important thing at this step is the individual's capability to self-regulate while learning. Pintrich, Smith, Garcia and McKeachie (1991) categorize self-regulated learning into two groups as self-regulation strategies and motivation. Considering this grouping, cognitive strategies included in self-regulation strategies consist of cognitive processes that are used by the students throughout the learning process (Boekaerts, 1999). The metacognitive strategies consists of controlling the learning process by collecting, arranging, planning, and evaluating the cognitions of the students (Demir & Doğanay, 2009). In this context, the concepts of cognition and metacognition in self-regulation strategies are different from each other. While cognition refers to the process of being aware of something and understanding it, metacognition means not only understanding and learning something but also knowing how to learn (Senemoğlu, 2004).

The introduction of metacognition in the literature coincides with the mid-1970s when behaviorism was replaced by cognitivism which puts the learner who takes an active role in accessing information into the foreground. There are various and similar definitions of metacognition made by different researchers. When the literature is reviewed, it is obvious that the most cited researcher on this subject is Flavell. Flavell (1987) defines metacognition as the knowledge of a person's cognitive process. Gunstone and Mitchell (1998) describes the term as individuals' recognizing and monitoring their cognitive processes while Blakey and Spence (1990) labels the term thinking how to think. Although there are many models related to metacognition, which are considered as planning learning and self-management strategies by Açıkgöz (2000), the most common classification of metacognition is divided into two conceptual categories as knowledge of cognition and regulation of cognition (Schraw & Moshman, 1995). Students' metacognitive knowledge and skills can be shaped depending on many factors. In this context, assessment is one of the important factors.

1.3. The Relationship between Assessment and Metacognition

It is highly important for the students to be active both in the learning and assessment process for building their metacognitive awareness (Jones, 2007). Furthermore, it is frequently emphasized in the literature that formative assessment plays a crucial role in the development of metacognitive skills that are based on controlling and questioning one's way of learning (Broadbent, Sharman, Panadero & Fuller-Tyszkiewicz, 2021; Hattie & Timperley, 2007). Therefore, different alternative assessment types, primarily making self-assessments, should be regarded as an integral part of the learning-teaching process in the assessment process carried out according to the formative assessment approach in order for metacognitive teaching to achieve its purpose (Yurdabakan, 2011).

There are a lot of studies conducted on the relationship between assessment and students' metacognitive skills and the effect of different assessment types on metacognitive skills. There are also some studies that especially emphasize the relationship between formative or alternative assessment and metacognition (Durmuş, 2013; Molin, Haalermans, Cabus & Groot, 2020; Wang, 2015). Wang (2015) examined the effects of four different assessment techniques used in the learning process on the metacognitive skills of chemistry students and found that the students' metacognitive skills were affected by the assessment

practices. In a similar study, Durmuş (2013) examined the effects of some alternative assessment techniques based on the multiple intelligences theory on students' metacognitive skills and concluded that the assessment techniques were effective in improving students' metacognitive skills. On the other hand, Braund and DeLuca (2018) investigated how primary school teachers used formative assessment to improve their students' metacognitive skills. The results of this study revealed that teachers thought that formative assessment was quite effective in developing students' metacognitive skills. Moreover, Hudesman et al. (2013), implemented the teaching program they created by integrating self-regulated teaching with formative assessment and developed for more effective learning of students in a three-year period. In this process, the effect of formative assessment and metacognition on student achievement was investigated. The results of the study indicated that the metacognitive development of the students included in this program was achieved and their levels of success was increased. In another similar study, Molin et al. (2020) found that peer discussions combined with teacher feedback as a formative assessment practice had a significantly positive effect on students' metacognitive awareness in their study conducted with 633 high school students in physics classes. Unlike these studies, in one of the studies on the relationship between self-assessment and metacognitive skills, Andrade (1999) found that self-assessment was especially effective in the development of metacognitive skills among female students. Likewise, Braund and DeLuca (2018) concluded that self-assessment and peer assessments are important in terms of metacognitive skills. The results of these studies show that there are significant relationships between students' metacognitive skills and formative assessment practices.

1.4. The Purpose and Significance of the Study

Although the effects of different assessment practices on students' metacognitive skills is an interesting and intriguing subject, the limited number of studies examining the relationship between metacognitive characteristics and assessment practices (Block, 2004; Wafubwa & Csíkos, 2021) highlights the need for new studies. On the other hand, it has been emphasized that there are important relationships between these variables in the limited number of studies (Andrade, 1999; Baas, Castelijns, Vermeulen, Martens & Segers, 2015; Braund & DeLuca, 2018; Fukuda, Lander & Pope, 2020; Shepard, 2019; Wang, 2020). In particular, learning-oriented assessment practices, in which the student actively participates in the learning process where feedback and corrections are properly made, enable students to learn effectively and think reflectively (Black & William, 1998). Many researchers have emphasized that formative assessment practices have a significant impact on students' ability to organize their learning (Granberg, Palm & Palmberg, 2021; Zimmerman, 2000).

The limited number of studies on the relationship between metacognitive skills and assessment practices, there are also studies based on the experimental design as in this study (Andrade, 1999; Braund & DeLuca, 2018; Durmuş, 2013; Molin et al., 2020). However, this study aimed to examine the effects of assessment carried out with different purposes and forms on students' metacognitive knowledge and regulation skills. Another distinctive aspect of this study is that 54 different alternative assessment techniques were used in the experimental implementation. In similar studies (Andrade, 1999; Braund & DeLuca, 2018; Durmuş, 2013; Hudesman et al., 2013; Molin et al., 2020; Taşkın & Çakmak, 2017) it is obvious that fewer alternative assessment techniques were used. However, in this study, by the nature of formative assessment (Cauley & McMillan, 2010), the process was enriched by using many diverse techniques. In this direction, within the scope of the study, the experimental implementation was carried out by taking advantage of the techniques used in other studies and, in addition to them, 54 different assessment techniques were put into practice within the framework of Science Assessment, Instruction and Learning Cycle (SAIL-C). Moreover, during the analysis of the metacognitive knowledge and skills of the students, the metacognitive knowledge (descriptive, procedural, conditional) and metacognitive regulation (planning, monitoring, evaluating) dimensions were investigated separately while the students' skills were examined in-depth through semi-structured interviews. The present study is aimed to investigate the effect of formative assessment practices on students' metacognitive knowledge and metacognitive regulation skills in science courses. Based on this general purpose, the sub-problems of the study are given below.

1.4.1. Is there a significant difference between the pre-test and post-test scores of the students on the Metacognitive Awareness Inventory (MAI-C) in the experimental, control, and placebo groups?

1.4.2. What is the level of metacognitive regulation skills (planning, monitoring, and evaluating) and metacognitive knowledge (declarative, procedural, and conditional knowledge) of the experimental group students before and after the experimental process?

2. METHOD

2.1. Research Model

This study is based on the mixed method. The main reason for selecting this method in the study is the necessity of collecting qualitative and quantitative data together due to the nature of the research problem. In this context, an embedded design, in which qualitative and quantitative data are collected simultaneously or sequentially, can be used to examine different research questions, and the analysis of data sets is carried out independently of each other, was used (Creswell & Plano-Clark, 2011). A quasi-experimental design was used with pre-test and post-test within experimental, placebo, and control groups in the quantitative part of the study, while a case study was used in the qualitative part.

2.2. The Study Group

This study, which was based on the mixed method, the multi-stage sampling method was used in the selection of the study groups for the qualitative and quantitative dimensions. The study group of the quasi-experimental design conducted in the quantitative dimension consisted of seventh-grade students studying in three different classes of a public secondary school. Classes with similar characteristics were randomly divided into three groups as experimental, control, and placebo groups. The study group of the experimental design consisted of 37 students in total, 12 students in the experimental and placebo group, and 13 students in the control group. The study group of the case study consisted of 12 students in the experimental group. Interviews were conducted with the students in this study group of 12 students before and after the experimental procedure.

2.3. Data Collection Tools

Quantitative and qualitative data were used together to examine the changes in students' metacognitive awareness in this study. "Metacognitive Awareness Inventory for Children" was used to obtain quantitative data. Qualitative data were collected through the interview form prepared by the researchers.

2.3.1. Metacognitive Awareness Inventory for Children

The scale was developed by Sperling, Howard, Miller, and Murphy (2002) to measure children's metacognitive skills. Since it aims to measure the metacognitive skills of different age groups, it consists of A and B forms prepared according to these age groups. The Turkish adaptation of the scale was carried out by Karakelle and Saraç (2007). The B form of the scale consisting of 18 items was developed for 6th, 7th, 8th, and 9th grade students (e.g. [item1] *"I know whether I can understand something"*; [item 18] *"I decide what needs to be done before I start a job"*). The internal consistency coefficient (Cronbach alpha value) of the B scale, which is a five-point Likert type and has a single factor structure, was found as .72.

2.3.2. Student pre- and post-interview form

While preparing the interview form, the relevant literature was reviewed, and interviews with students and examples of interview questions in the conducted studies were taken into consideration. The interview questions in Demircioğlu (2008)'s doctoral thesis were used as a basis. Since the metacognitive changes of the target group of students will be analyzed in-depth, the interview questions were prepared in line with the components of metacognition and expert opinions were sought. At this stage, in the light of expert opinions, probes were added to the interview form in order to elicit more detailed information from the students and to prevent possible incomprehension and misunderstanding. The questions were prepared in by the categories of knowledge and regulation of metacognition.

2.4. Procedure

2.4.1. Pilot study

The pilot study was carried out before the experimental procedure and completed in four weeks. A pilot study was performed by the researchers for 16 lessons in a different class from the class where the main study would be conducted. In this process, worksheets similar to those to be used in the main study were prepared and used in the class activities. Thanks to the pilot study, the researchers gained experience in eliminating the problems in the process, building awareness about the problems they might encounter, and developing solutions. Thus, many of the problems encountered in the pilot study were resolved in advance.

2.4.2. Procedures in Experimental Group

The experimental procedures of the study lasted for 14 weeks. The distribution of the procedures is shown in Table 1. Procedures are listed by weeks of administration.

Table 1.
The distribution of the procedures by weeks of administration

Procedures	Date
Administration of pre-tests and pre-interviews	1st week
Performing the study procedures in experimental, placebo, and control groups	2nd-13thweek
Administration of post-tests and post-interviews	14thweek

As seen in Table 1, the administrations in the experimental group started with pre-tests, selection of the students to be interviewed, and pre-interviews. Then, for 12 weeks, the applications in the experimental group were carried out according to SAIL-C developed by Keeley (2008), although the activities in the textbook were used in the teaching process. In this cycle, where formative assessment activities are carried out, alternative assessment techniques were also used. SAIL-C consists of six stages: *(i) engagement and readiness, (ii) eliciting prior knowledge, (iii) exploration and discovery, (iv) concept and skill*

development, (v) concept and skill transfer, and (vi) reflection and self-assessment. Different assessment techniques are used at all stages of this cycle according to the nature of the stage, which aims to blend the assessment and teaching process. Although metacognition and self-assessment are considered important at all stages in SAIL-C, they are highly emphasized especially in the last (reflection and self-assessment) stage. The main advantage of this cycle is the systematic integration of assessment activities into all stages. Considering that one of the most important features of formative assessment is that teaching and assessment are intertwined (Popham, 2008), SAIL-C provides a systematic framework for the teaching processes in which formative assessment is required. In the procedures carried out in the experimental group, the worksheets were designed by the SAIL-C and the lessons were taught for each topic. The topics and assessment techniques used in the experimental procedure are shown in Table 2. As seen in Table 2, 54 different techniques were used in the process. The techniques including portfolios, projects, journals, self-assessment, and peer assessment were used throughout the entire experimental process while other techniques included the worksheets prepared for different topics. In the experimental procedure, besides the techniques included in the worksheets throughout the term, the questions in the three written exams prepared for the experimental group included alternative assessment techniques. In the experimental group, the lessons were taught by the researcher (also the teacher).

Table 2.
Assessment Techniques Used in the Experimental Process

No	Technique	The Topic
1	Concept map	Reflection in Mirrors
2	Friendly Talk Probes	Reflection in Mirrors
3	Ten-Two	Reflection in Mirrors
4	Concept Card Mapping	Reflection in Mirrors
5	Think-Pair-Share	Reflection in Mirrors
6	Structured communication grids	Reflection in Mirrors
7	Two-Minute Paper	Reflection in Mirrors
8	Knowledge-Wanted-Learning cards	Absorption of Light
9	Chain Notes	Absorption of Light
10	Informal Student Interviews	Absorption of Light
11	Annotated Student Drawings	Absorption of Light
12	Data Match	Absorption of Light
13	Diagnostic Branching Tree	Absorption of Light
14	Muddiest Point	Absorption of Light
15	Interest Scale	Colours
16	Volleyball-Not Ping-Pong!	Colours
17	Partner Speaks	Colours Conversion of Electrical Energy
18	Give Me Five	Colours
19	Predict -Explain-Observe-Explain	Colours
20	Agreement Circles	Colours
21	Performance Assignments	Colours Ecosystem
22	Traffic Light Cards	Colours
23	First Word-Last Word	Ecosystem
24	Concept Cartoons	Ecosystem
25	Analogy	Ecosystem Electrical Energy
26	Three-Minute Pause	Ecosystem Connecting the Light Bulbs
27	Card Sorts	Ecosystem
28	Poster	Ecosystem
29	Focused Listing	Biodiversity
30	Sticky Bars	Biodiversity
31	No-Hands Questioning	Biodiversity Electrical Energy Conversion of Electrical Energy
32	Fishbowl Think Aloud	Biodiversity
33	Commit and Toss	Biodiversity
34	I Used to Think…But Now I Know	Biodiversity
35	Point of Most Significance	Biodiversity
36	Word association	Connecting the Light Bulbs
37	Paint the Picture	Connecting the Light Bulbs
38	RERUN	Connecting the Light Bulbs
39	Two Stars and a Wish	Connecting the Light Bulbs
40	Traffic Light Cups	Connecting the Light Bulbs
41	Juicy Questions	Electrical Energy
42	Fist to Five	Electrical Energy
43	Sequencing	Electrical Energy
44	White boarding	Electrical Energy
45	Prefacing Explanations	Conversion of Electrical Energy

46	Justified True or False Statements	Conversion of electrical Energy
47	Poster	Conversion of electrical Energy
48	Learning Goals Inventory	Conversion of electrical Energy
49	Look Back	Conversion of electrical Energy
50	Project	During Experimental Process
51	Portfolio	During Experimental Process
52	Journal	During Experimental Process
53	Peer assessment	During Experimental Process
54	Self-assessment	During Experimental Process

2.4.3. Procedures in Control Group

Similar to the experimental group, the activities in the textbooks of the students were used during the lessons. Although the activities were the same as in the experimental group, a separate worksheet was not used in the control group. Unlike the experimental group, the lessons were not taught according to the SAIL-C (conducted according to the curriculum), and traditional techniques such as multiple choice tests, true-false and blank filling activities were used in the process. As in the experimental group, teaching-learning activities lasting for 12 weeks were carried out by the researcher and assessment techniques were prepared by the researchers.

2.4.4. Procedures in Placebo Group

Similar to the experimental and control groups, the activities in the textbooks of the students were used during the lessons in the placebo group. Unlike the control group, the students in the placebo group were taught using the worksheets provided that the activities in the textbooks were the same. In addition, assessment practices in the placebo group were carried out according to the curriculum, as in the control group, and traditional techniques were used in the procedure. As in the experimental and control groups, teaching-learning activities lasting for 12 weeks were carried out by the researcher and assessment techniques were prepared by the researchers.

2.5. Data Analysis

The quantitative data obtained from all the groups were analyzed by utilizing the PASW 18.0 package program. Before the analysis of the data, hypothesis tests were examined. Based on the small number of participants in the study group and the results of the normality assumption tests, the data were analyzed with non-parametric tests. In the comparison of the pre-test and post-test scores of the students of the experimental, control, and placebo groups, Kruskal-Wallis Test and Mann-Whitney U Test were used. The result of the Kruskal-Wallis test indicated that there was a significant difference between the post-test scores of the groups, and the differences between the paired combinations of the groups were examined with the Mann-Whitney U test.

In the analysis of qualitative data, descriptive analysis and categorical content analysis, which is one of the content analysis types, was used. The categorical content analysis process includes several stages such as (i) coding the data, (ii) creating the themes [categories], (iii) organizing the themes (vi) defining the findings. Since it is an effective tool for organizing and storing data, it was decided to carry out this analysis on a computer. In the process that started with the transfer of the voice recordings to the Microsoft Word document, the analysis was made using NVIVO 11 package program.

2.6. Validity and Reliability of the Study

2.6.1. Validity and Reliability of the Experimental Procedure

Conducting the research as objectively as possible is a criterion for validity (Kirk & Miller, 1986). From this point of view, validity gives information about the accuracy of any research. Therefore, negative situations that affect validity should be paid attention to in the experimental process (Creswell, 2005). Internal validity is defined as the adequacy of the procedures throughout the research in revealing the studied reality (LeCompte & Goetz, 1982). The main factors that threaten internal validity in experimental research include a selection of the subjects, maturation, instrumentation, subject loss effect, pre-test effect, biased grouping effect (Büyüköztürk, 2001).

In this study, control and placebo groups were included in the research design as one of the ways to increase internal validity. The effect of the expectations of the individuals participating in the study about the experimental conditions on the results of the research is called the Hawthorne effect. In other words, the Hawthorne effect means that the individuals participating in the study realize that they have been selected for the experiment, and in this case, they tend toward this expectation, thinking that a positive behavior change is expected from them. To eliminate this effect in the study, the placebo group was included in the experimental process. On the other hand, to minimize this effect, the activities were carried out by the researcher, who was the formal teacher of the course as different schools and researchers were selected for the study and students experienced a different learning environment than they were accustomed to. The Hawthorne effect may be encountered due to both teacher and teaching method changes. Therefore, the researcher, who was also the formal teacher of the course, carried out the activities

in order to reduce the risks of teacher change (Kocakaya, 2011). On the other hand, it remains an important issue to tell students or to make them feel that their success in this experimental study will be assessed in their school grades in the experimental studies conducted by both the researcher and the formal course teacher (Kocakaya, 2012). To be able to control this challenge, the researcher ensured that the teaching process would continue in its natural flow as much as possible and that the students would not have such a feeling. On the other hand, by using the same data collection tool in all assessments, any issues related to the internal validity that may arise from the data collection tools were attempted to be resolved. To prevent biased grouping, which is another threat, the experimental, control, and placebo groups were formed by drawing lots and neutral assignments. In this way, it was ensured that the maturation effect could be controlled. In addition, expert opinion was taken about the worksheets prepared during the implementation process.

2.6.2. Validity and Reliability of the Case Study

In the case study section of the study, attention was paid to ensuring internal validity, construct validity, and reliability. To increase the validity of the study, methods such as having an unbiased attitude, taking expert opinions, making face-to-face interviews, and conducting the process with a study group suitable for the purpose (Creswell, 2005) were used. To increase the reliability of the study, methods such as being impartial in the data analysis and explaining the data collection and analysis process by making direct quotations with necessary details were used.

3. FINDINGS AND DISCUSSION

3.1. Quantitative Findings

Kruskal Wallis Test results regarding the comparison of the pre-test scores obtained from the MAI-C of the students in the experimental, control, and placebo groups are given in Table 3.

Table 3.
Kruskal Wallis Test Results Regarding the Comparison of the Pre-Test Scores Obtained From the Mai-C of the Students in the Experimental, Control, and Placebo Groups

Groups	n	Mean rank	df	χ^2	p
Experimental	12	20.83			
Control	13	17.58	2	0.579	.75
Placebo	12	18.71			

According to the Kruskal Wallis test result, there is no significant difference between the pre-test scores of the students in the experimental, control, and placebo groups (p>.05). This finding shows that the students' metacognitive awareness in the experimental, control, and placebo groups were similar before the experimental procedure. The Kruskal Wallis test result regarding the comparison of the post-test scores of the students are shown in Table 4.

Table 4.
Kruskal Wallis Test Results Regarding the Comparison of the Post-Test Scores of the Students Obtained from the MAI-C in the Experimental, Control, and Placebo Groups

Groups	n	Mean rank	df	χ^2	p
Experimental	12	29.08			
Control	13	15.77	2	16.058	> .001
Placebo	12	12.42			

According to the Kruskal Wallis test results in Table 4, it is obvious that there is a significant difference between the post-test scores of the students in the experimental, control, and placebo groups. Since the difference between the groups was significant (p<.05), the differences between the paired combinations of the groups were examined with the Mann-Whitney U test to determine which groups the difference was due to, and the results of the Mann-Whitney U test are shown in Table 5.

Table 5.
Mann-Whitney U Test Results Regarding the Comparison of the Post-Test Scores of the Students Obtained from the MAI-C in the Experimental, Control, and Placebo Groups

Groups	n	Mean rank	Sum of ranks	U	p
Experimental	12	17.96	215.50	18.500	.001
Control	13	8.42	109.50		
Experimental	12	17.63	211.50	10.500	>.001
Placebo	12	7.38	88.50		
Control	13	14.35	186.50	60.500	.34
Placebo	12	1.54	138.50		

Based on the data presented in Table 5, it is seen that there is a significant difference between the post-test mean scores of the students in the experimental-control group and the experimental-placebo group (p<.05). Considering the mean ranks, it is

notable that this difference is in favor of the experimental group. On the other hand, the difference between the control, and placebo groups was not significant (p>.05). Accordingly, after the procedure, there was a significant increase in the metacognitive awareness levels of the experimental group students compared to other groups. In the light of these findings, it can be argued that the formative assessment practices performed during the experimental procedure proved to be effective in increasing the metacognitive awareness levels in the experimental group students.

3.2. Qualitative Findings

The metacognitive skills of the students in the study group were analyzed using categories such as metacognitive knowledge (declarative, procedural, and conditional) and metacognitive regulation skills (planning, monitoring, and assessment).

3.2.1. Findings on metacognitive knowledge

The students' metacognitive knowledge levels were examined under three categories as declarative, procedural, and conditional knowledge (Jacobs and Paris, 1987; Schraw, Crippen, & Hartley, 2006).

3.2.1.1. The findings related to declarative knowledge

Declarative knowledge refers to the facts and information about the factors affecting the learners themselves and their performance (Schraw et al., 2006). Some declarative questions were asked to the students in pre- and post-interviews. Fig. 1 includes a model showing the categories and subcategories of the students' declarative knowledge in the pre- interview. The frequency data were presented under four main categories created by the students' responses.

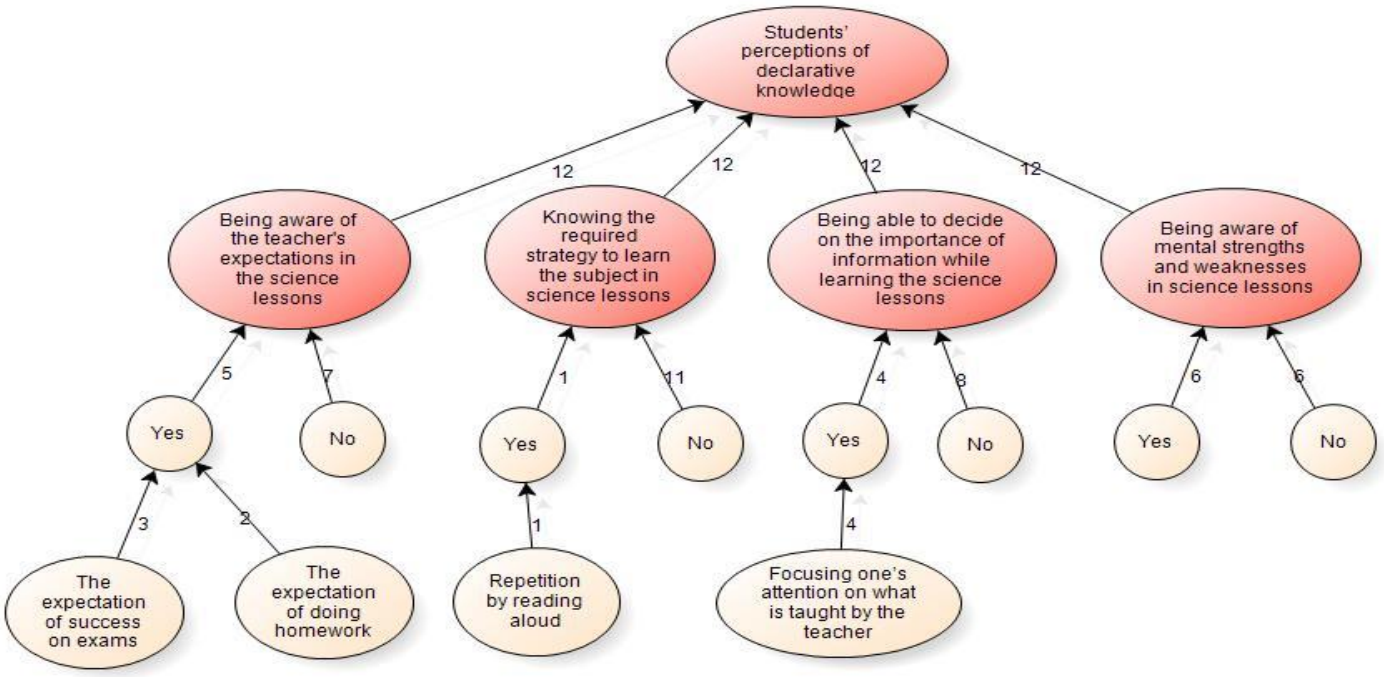

Figure 1. A model showing the categories and subcategories of the students' declarative knowledge in the pre-interview.

The first category is related to being mentally aware of personal strengths and weaknesses in the model. Half of the students stated that they were aware of their strengths and weaknesses while the other half stated that they were not. However, those students who stated that they were aware of their strengths and weaknesses didn't mention any relevant situations, which can be interpreted that they lack of awareness or necessary skills to some extent. An example statement from the responses of the students is presented below.

"Mentally? There are some good and bad ones, too. I am more successful in some fields." (s_4)

In Fig. 1, considering the students' capability to decide on the importance of the knowledge during the science lessons, four students stated that they could achieve this. When asked how they could decide on this situation, they stated that they thought the topics emphasized more by their teachers were more important. However, eight students stated that they were unable to do so. In this case, it can be argued that the students are not aware of the usefulness of the information they learn yet. Therefore, it can be interpreted that the level of awareness of students about how they learn may also be low. An example statement from the students' responses is as follows;

"Yes, it is the most important information the teacher emphasizes at most, so I can decide in that way." (s_7)

The third category in Fig. 1 is associated with awareness of the teacher's expectations. Five students stated that they were aware of their teachers' expectations from them, but seven students were not aware of such expectations. When those students who were aware of their teachers' expectations were asked what kind of expectations their teachers had, they stated that their teachers wanted them to be successful on their exams, study hard, and do their homework regularly. At this point, the students stated that their teachers held result-oriented opinions and expected them to pass their exams. At the same time, many students stated that they started studying only when they were given assignments or homework. In this case, it can be said that the students do not actively structure their own mental processes, but rather emphasize success in exams. An example statement from the students' responses is as follows;

"Our teacher expects from us to be successful like our other teachers do." (S_{11})

In Fig. 1, the last category is related to using traditional strategies to learn a subject. 11 of the students didn't know these types of strategies while only one knew them. The only student stating that he/ she knows different strategies reported that he/ she regularly revised the subject verbally after studying. However, the fact that the majority of students are not aware of such strategies can be regarded as a challenge in terms of declarative knowledge since it is important to be conscious of what to know and what is not known. An example statement from the students' responses is as follows;

"There are things that contribute to my success. For example, after studying the subject thoroughly at home, I learn best by teaching and repeating myself the subject verbally in the same way as my teacher does at school." (S_5)

Fig. 2 includes a model showing the categories and subcategories of the students' declarative knowledge in the post-interview. The frequency data were presented under four main categories created by the students' responses.

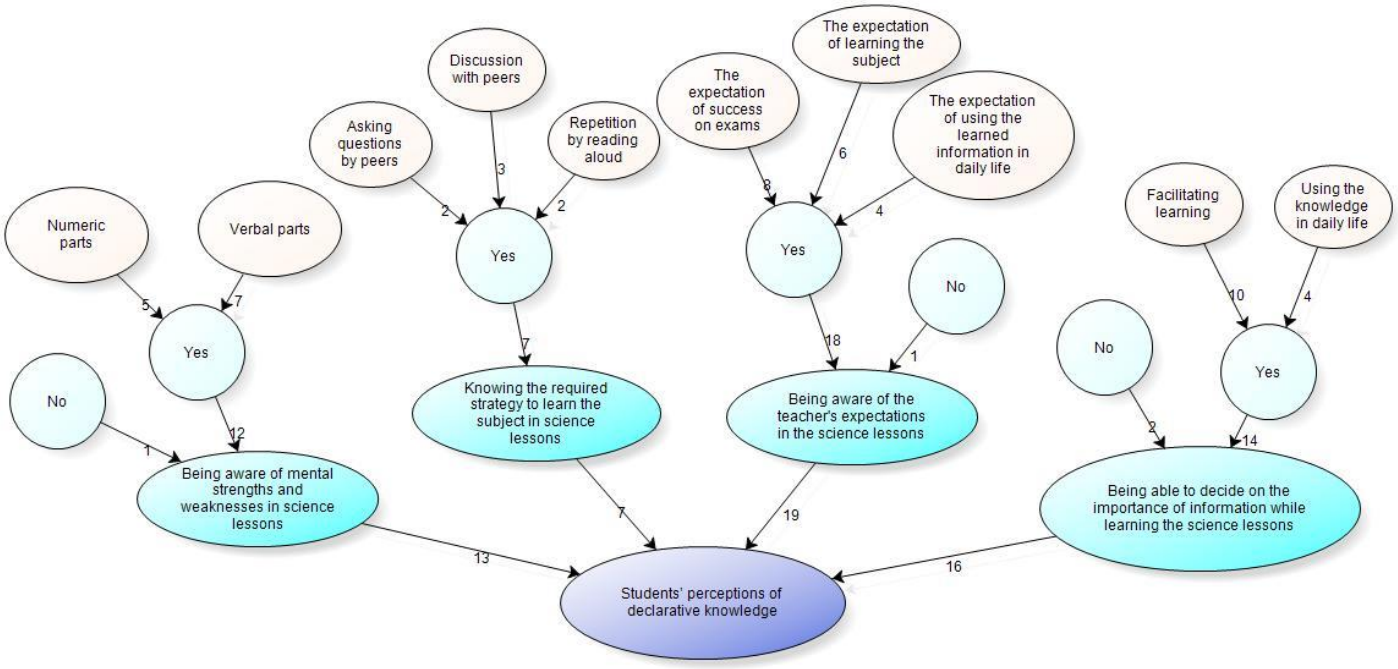

Figure 2. A model showing the categories and subcategories of the students' declarative knowledge in the post-interview

Fig. 2 which was created by the students' statements on declarative knowledge in the post-interview, shows the first category related to being mentally aware of personal strengths and weaknesses. The majority of the students stated that they were aware of their strengths and weaknesses while only one student stated the contrary. When the students who were aware were asked about their strengths and weaknesses, some reported that they were good at maths due to their developed skills in making mathematical operations. However, some others stated that they were better at reading, listening, and summarizing. Therefore, the students' skills were presented in verbal and quantitative categories. Five students reported that they were good at quantitative subjects while seven students reported that they were good at verbal subjects. The fact that the students are aware of their strengths and weaknesses is also important given declarative knowledge as it promotes cognitive awareness. The students' responses seem to indicate that they are highly aware of this subject. An example statement from the responses of the students is presented below.

"Yes, I think I am better at verbal skills such as reading, writing, and speaking in the science lessons" (S_5)

In Fig. 2, considering the category in which the students could decide on the importance of the scientific information in the science courses, 10 students stated that they could decide which information is important while learning. The two students stated that they couldn't make this decision. Those who could make a decision were asked how they could do that. Some students

stated that they paid attention to whether the quality of information facilitated their learning. They thought that the information taught was important if it could make topics easier to learn. At the same time, they also reported that the information taught is significant to the extent that it could be adapted to daily life. Here, it can be argued that the students sought functionality in the information taught, which a positive development for metacognition is. An example statement from the responses of the students is presented below.

"The information that makes me learn a topic easier for me matters" (s_7)

The third category includes the students' awareness of the teachers' expectations of them in Fig. 2. Eleven students stated that they were aware of their teachers' expectations of them, but one student was not aware of such expectations. When they were asked about their teachers' expectations from them, they stated that their teachers wanted them to be successful and learn the subjects well. Some students also stated that their teachers expected them to be able to use the skills and subjects they learned in their daily life. In this context, it can be suggested that the students have examination-oriented thoughts and attitudes as well as focusing more on comprehension, learning, and practicing the learned skills. These findings can also indicate that the students perceive the classroom environment with their metacognition. An example statement from the responses of the students is presented below.

"Teachers expect us to be successful and at the same time to understand the subject." (s8)

In the last category in Fig. 2, the responses to the questions about knowing the required strategy to learn a subject in the science course. Five students reported that they knew these strategies while seven students stated that they didn't know. When the students who knew the strategies were asked about the kind of strategies they developed, two students stated that they reviewed the subjects verbally on their own, three students discussed the subject with their friends and two students asked questions to their friends about the subject, thus learned better. Thus, the students were able to express the factors that were effective in their learning. In line with that, it can be said that the students developed their skills related to declarative knowledge. An example statement from the responses of the students is presented below.

"I am teaching myself as a teacher after trying to learn the subject. Then we discuss it with my friends, so I learn it easily."(s_5)

3.2.1.2. The findings related to procedural knowledge

Procedural knowledge refers to the information related to the strategies and procedures required to achieve the purpose (Jacobs & Paris, 1987; Schraw et al, 2006). In pre- and post-interviews, some questions were asked about the procedural knowledge to the students. Fig. 3 includes a model showing the categories and sub-categories of the procedural knowledge in the pre-interview. The frequency data were presented under three main categories created by the students' responses.

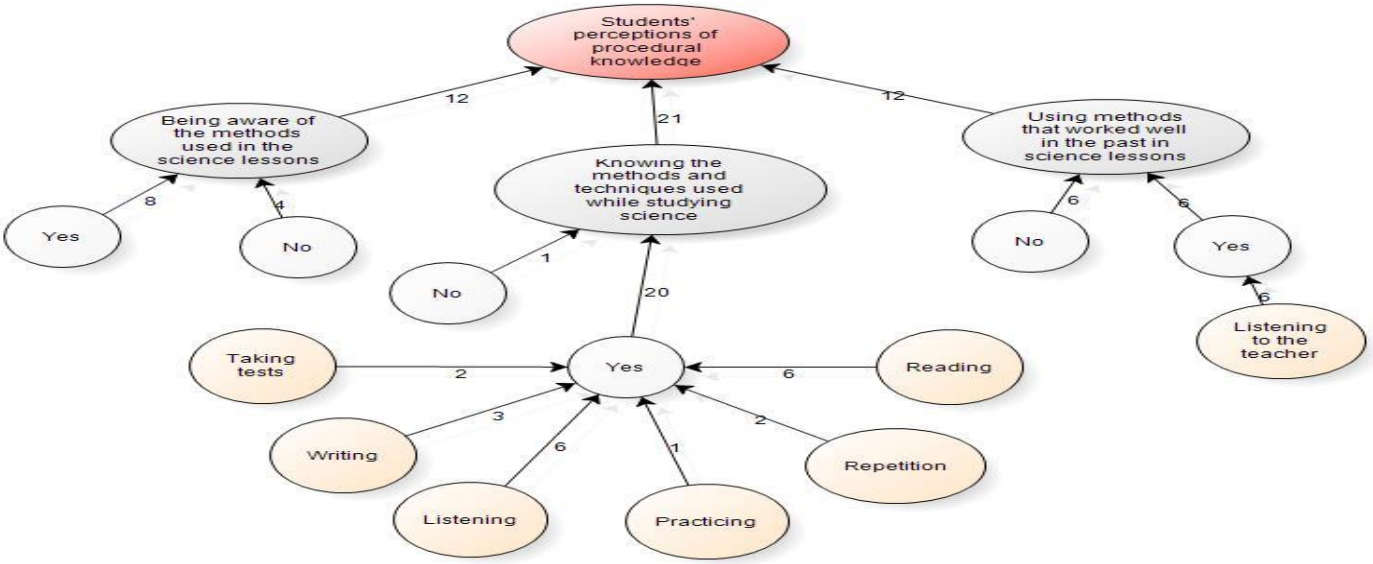

Figure 3. A model showing the categories and sub-categories of the procedural knowledge in the pre-interview

In Fig. 3, in the category of being aware of the methods used in science courses, the majority of the students were aware of the methods they used. Four students reported that they were not aware. When the students who were aware of the methods were asked to explain this case, they couldn't find any supporting statements for their responses. Although the students are aware of the methods, the fact that they cannot make sufficient explanations can be interpreted that they are not completely aware of the methods as they stated. An example statement from the responses of the students is presented below.

"Yes, I am aware of the methods but unable to give specific examples." (s_6)

The students were asked about their knowledge of methods and techniques they used when learning a subject in science courses, 11 students stated that they used such methods and techniques, but one student stated that he/she didn't use them. As shown in Fig 3., most of the students stated that they learned through listening and reading. Some students added that they learned by taking notes, testing, and reviewing the subjects. A student stated that he/she learned by doing and experimenting. In the light of these data, it can be said that the majority of students learn from traditional methods. An example statement from the responses of the students is presented below.

"*What makes me learn the subjects easily involves reading, listening to the teacher more carefully, revising at home, and taking a test.*" *(s_3)*

Considering Fig. 3, the last category included the distribution of the responses to whether the students used effective methods in the past. In this regard, six students stated that used the methods and techniques they consider to be effective in the past. When they were asked how they used them, they stated that they try to remember and use their past knowledge while learning the subject and listening to the teacher carefully. Although the students are expected to respond to the questions related to their learning management, the fact that they learn by listening to the teacher carefully suggests that they are dependent on external factors and lack procedural knowledge. The remaining six students had negative responses may also show that they are not effective in their learning. An example statement from the responses of the students is presented below.

"I never use the previous methods because they are effective on the previous subjects. I won't do more than anything." (s_1)

Fig. 4 includes the model that shows the categories and subcategories for the procedural knowledge of the students in the post-interview. In this context, the data on procedural knowledge were evaluated under three main categories.

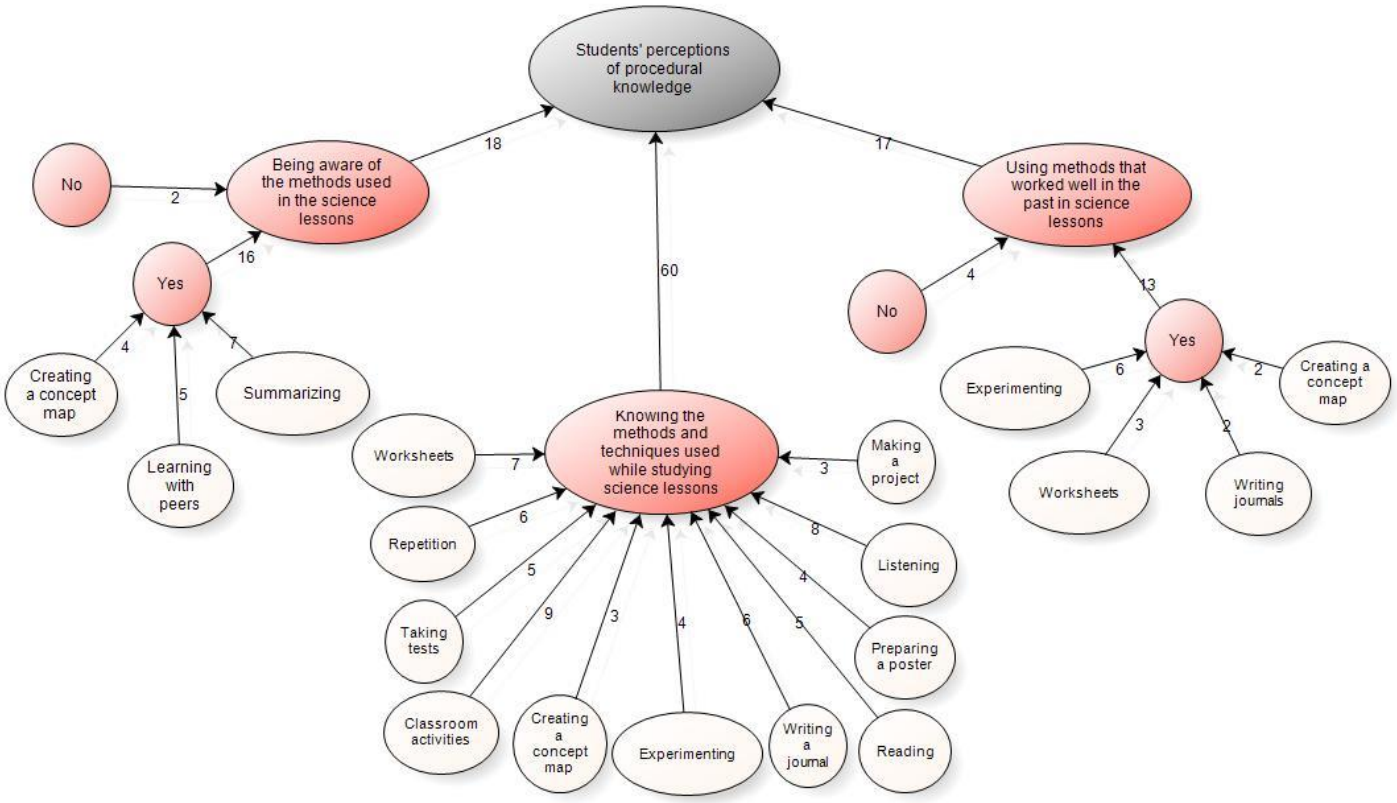

Figure 4. The model showing the categories and subcategories for the procedural knowledge of the students in the post-interview

Considering Fig. 4, the majority of the students were aware of the methods applied in science courses. Two students stated that they were not aware of such methods. Seven students who responded positively stated that they studied the topics by summarizing, five of them using concept maps and four of them studying with their peers. In the post-interview, it is remarkable that the students stated that they used the methods increasingly. This may indicate that the self-questioning level is increased due to awareness of why they do. An example statement from the responses of the students is presented below.

"I learn better in performing activities with my friends. It is also effective to draw shapes and make concept maps."(s_{10})

All the students reported that they knew the methods and techniques used in learning a subject in science courses. When they were asked about what kind of methods and techniques they used, eight students stated that they just listened to their teacher during the lessons, seven students using worksheets, and nine students learning through the techniques embedded into the activities. Moreover, some students stated that they learned better by reading, solving tests, and making revisions. Six students stated that they learned better thanks to the journals they wrote, four students through posters, and three students by preparing concept maps and projects that they made on their own in both courses and individual works. Four students stated that the experiments were effective in their learning and that they learned better by. The methods and techniques they use when learning students learn are an important development in terms of procedural knowledge involving the process of how learning takes place. An example statement from the responses of the students is presented below.

> *"I learn through the activities in the classroom, by listening, activities, doing homework, studying worksheets at home, keeping a journal." (s_2)*

Considering the last category in Fig. 4, the majority of students stated that they used effective methods in the past while four students didn't use such methods. It was also asked how the students used such methods. The students stated that they such learning techniques as experiments, worksheets, journals, and concept maps so that they could easily remember and use the information they learned. It is an important finding that students know the effective methods and techniques, which will provide a background for their future learning. An example statement from the responses of the students is presented below.

> *"I often use these methods. For example, a previous work of mine comes to my mind while learning a topic. The worksheets include activities to be associated with daily life, which reinforces my learning and increases my motivation to learn. The experiments also work well." (s_6)*

3.2.1.3. The findings related to conditional knowledge

Conditional knowledge refers to knowing a specific strategy and when to use it (Schraw et al., 2006). Some questions about conditional knowledge were asked in the pre- and post-interviews. Fig. 5 includes the model showing the categories and sub-categories of the students with the conditional knowledge in the pre-interview. In this context, the frequency data were presented under three main categories created by the students' responses.

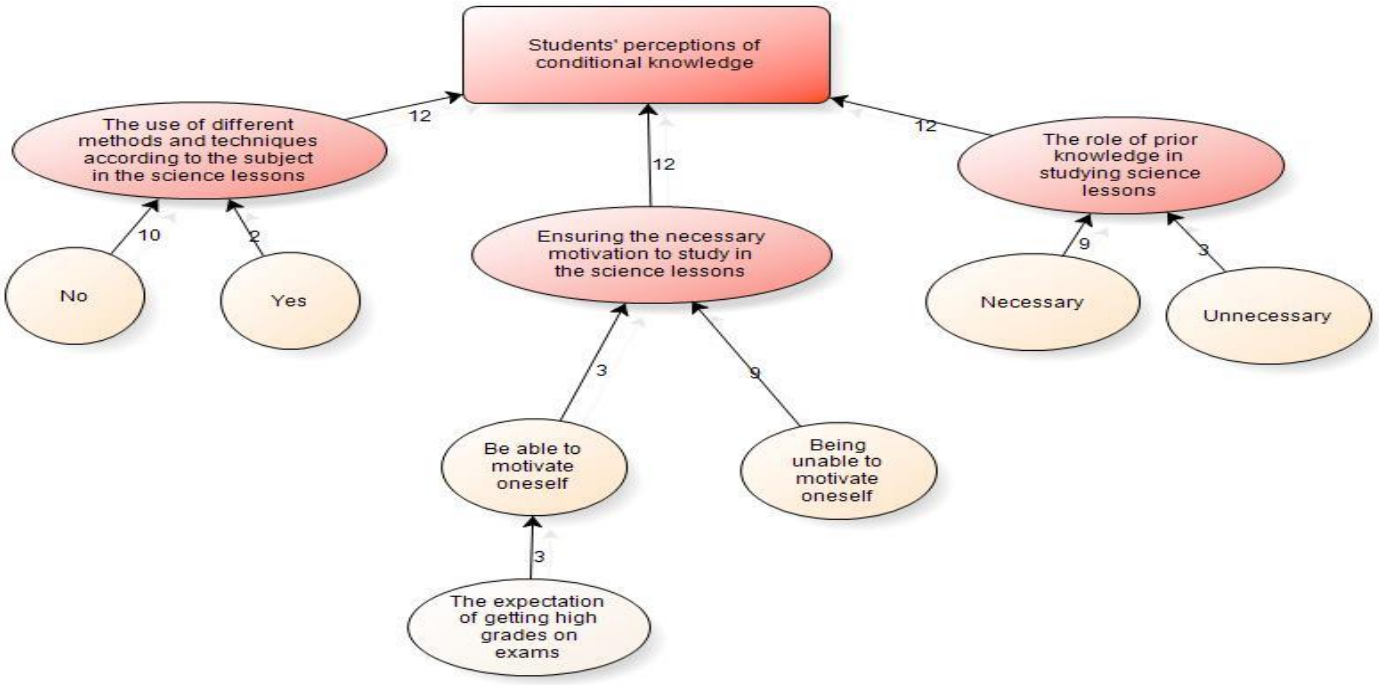

Figure 5. The model showing the categories and sub-categories of the students with the conditional knowledge in the pre-interview

When the role of the prior knowledge category is examined in Fig. 5, nine students stated that prior knowledge was necessary for learning a new subject while three students stated otherwise. However, when the students who that prior knowledge was necessary were asked about the reason for that, they couldn't explain it, which may indicate that the students don't interpret their learning process consciously and their conditional knowledge levels are relatively low. An example statement from the responses of the students is presented below.

> *"I only care about learning at that moment. The previous knowledge is not useful." (s_1)*

In Fig. 5, in the second category for the use of different methods and techniques, while two of the students stated that they used different methods, ten students stated that they didn't do so. Two students who reported using the methods were asked to explain how to use these methods and failed to provide examples. This can be interpreted as the students who responded positively to the questions related to the situation couldn't inform about how to do it. An example statement from the responses of the students is presented below.

"I use different methods according to the subjects." (s_5)

Considering the third category in Fig. 5, three students motivated themselves to learn the subjects in the science lessons while nine students couldn't. Stating that they motivated themselves, those students stated that they managed to do it by encouraging themselves to take high grades on the exams. This may indicate that the students focus on results and aim be successful in the exams. An example statement from the responses of the students is presented below.

"I can motivate myself. I'm always telling myself to do that. I am rather motivated by the fact that I need to take high grades in the exams." (s_4)

Fig. 6 includes the model showing the categories and subcategories regarding the conditional knowledge of the students in the post-interview. The frequency data were presented under three main categories created by the students' responses.

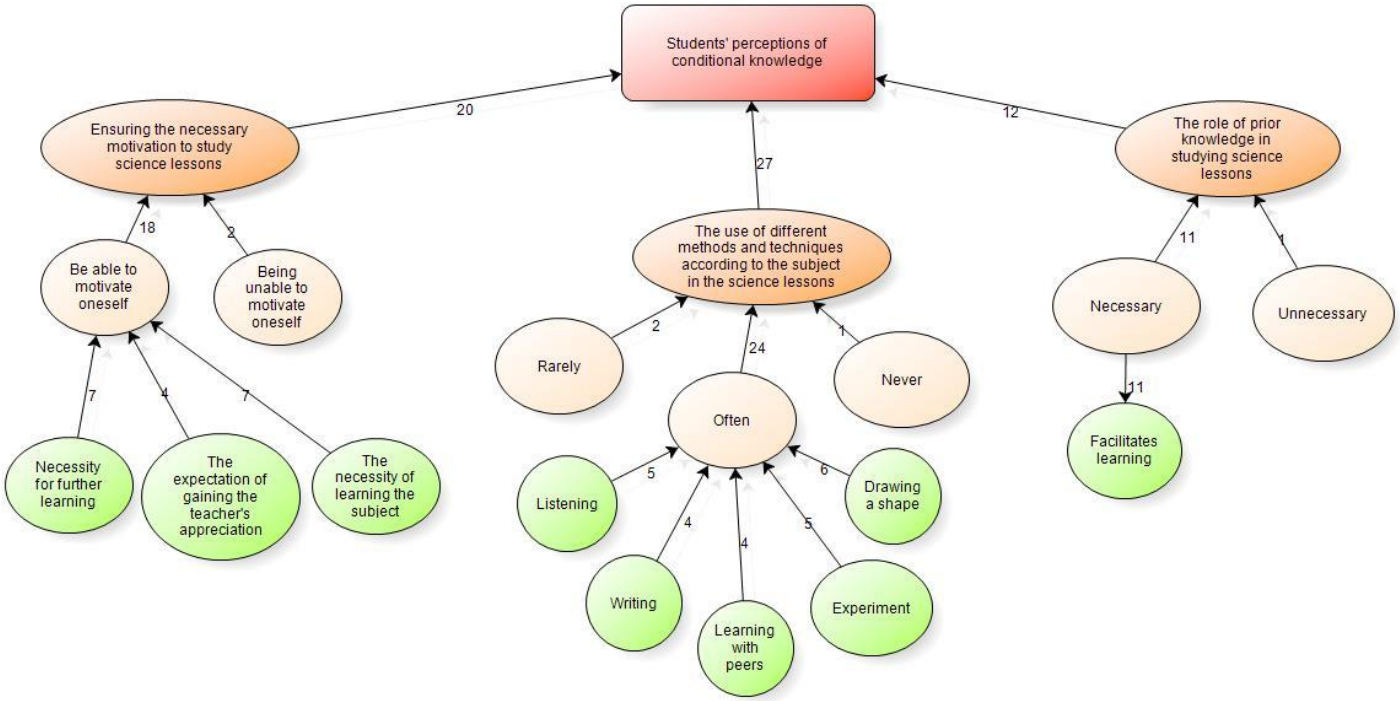

Figure 6. A model showing the categories and subcategories regarding the conditional knowledge of the students in the post-interview

In Fig. 6, when the role of the prior knowledge category is examined in learning the sciences course, 11 students stated that the prior knowledge is necessary for learning new a topic. When these students were asked why the prior knowledge was necessary, they stated that it facilitated learning. This may also show that the students are aware of the necessity of prior knowledge for new learning. An example statement from the responses of the students is presented below.

"I think I can learn the subjects we have prior knowledge." (s_8)

In Fig. 6, in the second category related to using a different method according to the subject, one of the students stated that he/she don't use a different method. While two students stated that they rarely used different methods, nine students stated that they frequently used different methods. Those students who stated about the frequency of using these methods were asked what kind of methods and techniques they used. The students stating that they rarely used these methods couldn't specify examples. The students stating that they frequently used different methods mentioned that doing experiments, drawing shapes, writing and listening, and studying with their friends enhanced their learning process in some topics. Thus, the fact that they can use different techniques according to different subjects and transfer their learning to new situations may indicate that the students develop metacognitive skills. An example statement from the responses of the students is presented below.

"The method varies on the subject. Writing, doing experiments or just drawing things may sometimes work better for learning." (s_1)

In Fig. 6, the last category is related to providing the necessary motivation to learn. Nine students stated that they be self-motivated but three students couldn't do so. The students stating that they could self-motivate made explanations for how they achieved this. These students emphasized the need to learn the topic, thinking that they would benefit from them in the future learning and be appreciated by the teacher, which motivated them. The students need to be motivated since this makes it easier to learn. This is a positive indicator for metacognitive skills to ensure that in the post-interview. An example statement from the responses of the students is presented below.

> *"When I achieve something good and am praised by the teacher, I'm motivating myself more from. I can also perform better as they are also motivating for me." (s_{11})*

3.3.1. The findings related to metacognitive skills

The metacognitive skills of the students were analyzed under three major categories compatible with the literature; planning, monitoring, and evaluating skills (Jacobs &Paris, 1987; Schraw et al., 2006).

3.3.1.1. The findings related to planning skills

Planning is the first step in regulating metacognitive knowledge. Planning refers to the selection of appropriate strategies and resources to perform any task (Schraw and Moshman, 1995). In pre- and post-interviews, some questions relevant to planning skills were asked. Fig. 7 includes a model showing the categories and subcategories of the students' planning skills in the pre-interview. In this context, the frequency data were presented under four main categories created by the students' responses.

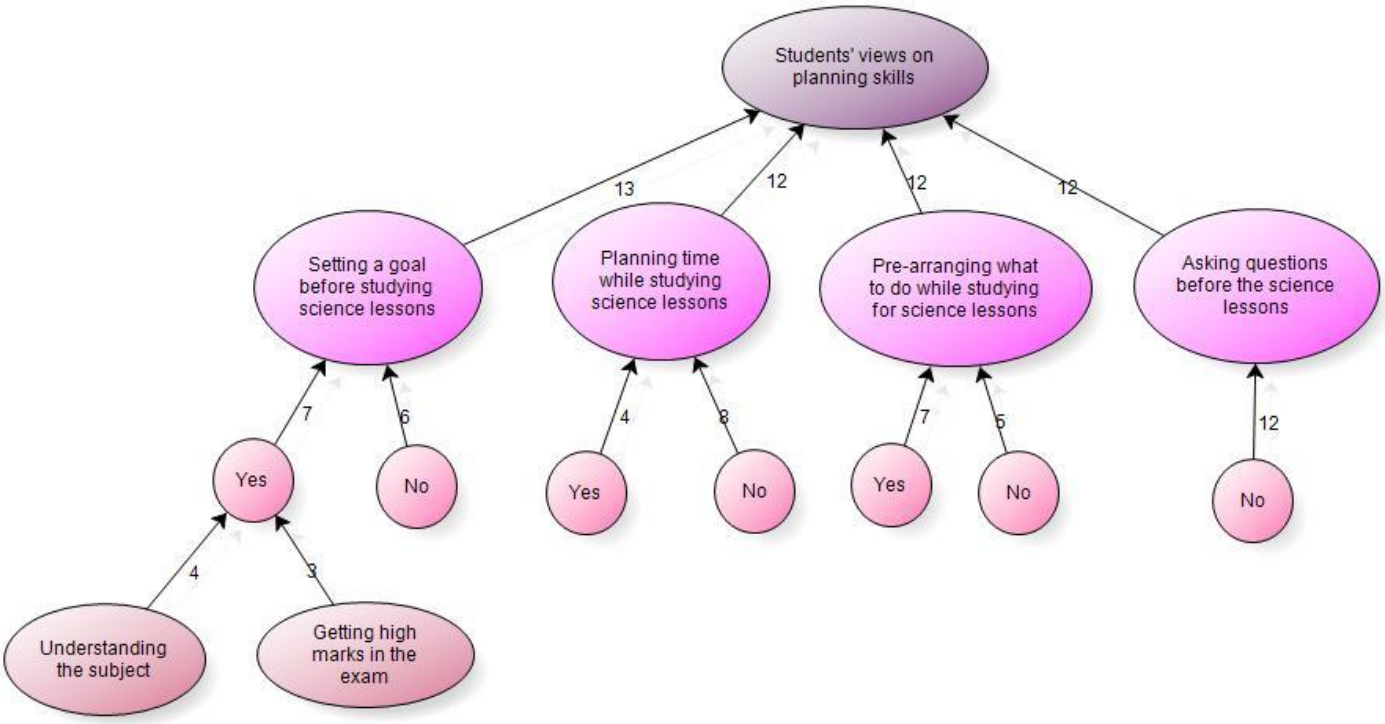

Figure 7. The model showing the categories and subcategories of the students' planning skills in the pre-interview.

In Fig 7, the first category includes setting goals for the students before studying science. Six students stated that they set goals before studying science. Some of these students aimed to understand the topic while some of them aimed to get high marks in the exams. However, six students stated that they didn't set any goals before studying science. The presence of exam anxiety among the responses of the students who stated that they set goals can be interpreted that the students take the external factors into account. An example statement from the responses of the students is presented below.

> *"Yes, I set my goals. My goal is to take high grades from the exam, so I only study before the exams. " (s_2)*

Another category in Fig. 7 is related to asking personal questions about the subjects to be learned before science lessons. All students stated that they didn't ask themselves such questions about the subject they will learn about. It can be argued that the students' planning skills are not developed because planning skills require the person to think before moving into action. The results show that the students do not have such ideas in mind. An example statement from the responses of the students is presented below.

> *"No, it is ridiculous to ask such questions before the lesson since I know nothing about the subject to be learned." (s_7)*

In Fig. 7 the third category refers to arranging things to do in advance. Seven students stated that they arranged themselves before science lessons, but they didn't specify the details. Five students stated that they didn't have an arranged scheme while studying science. Individuals with planning skills are required to develop their strategies before taking action. However, the students who stated that they arranged things are not aware of what they are doing. An example statement from the responses of the students is presented below.

"I sometimes make arrangements without a regular plan." (s_8)

Another category in Fig. 7 is related to the planning of time while studying. While four students stated that they used their time efficiently, eight students stated that they couldn't do so. The students who stated that they used their time efficiently couldn't make any explanation when they were asked about what they did in the time management. Time management in planning skills is also quite important to put things in order. However, it can be suggested that the students' time management skills are not well developed. An example statement from the responses of the students is presented below.

"I think I am using the time efficiently but without any particular plan." (s_4)

Fig. 8 includes a model showing the categories and subcategories of the students' planning skills in the post-interview. In this context, the frequency data were presented under four main categories created by the students' responses.

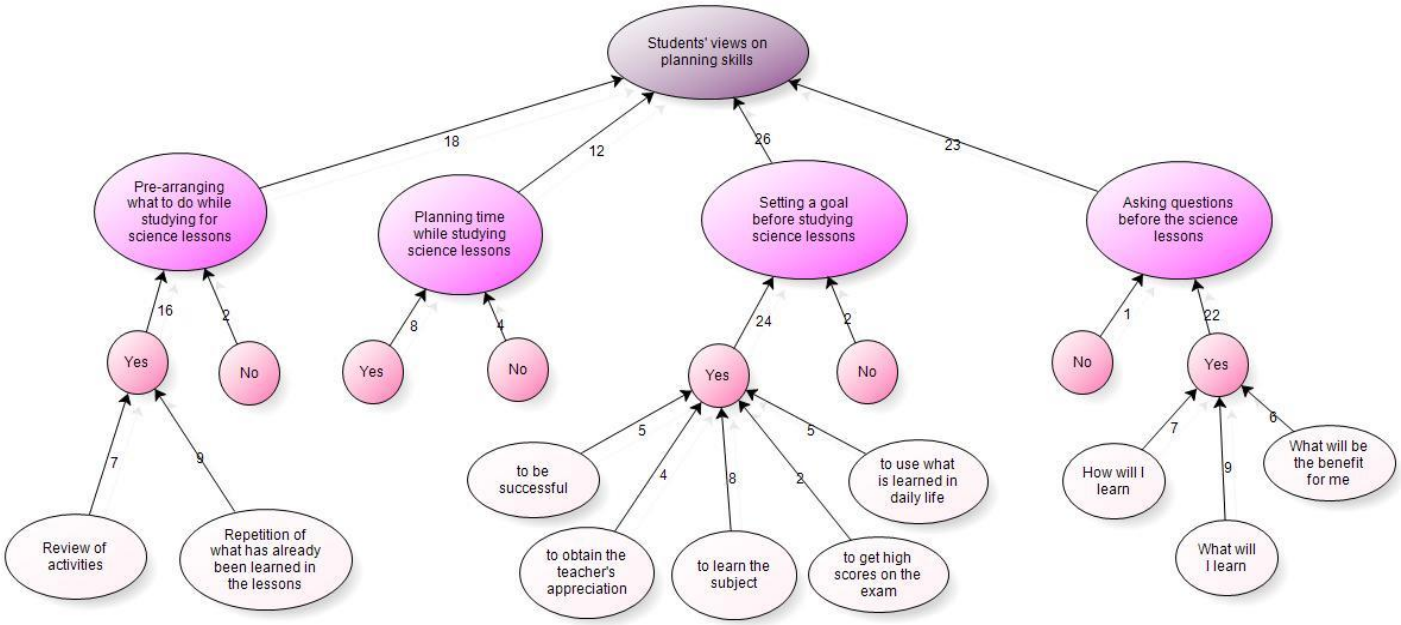

Figure 8. The model showing the categories and subcategories of the students' planning skills in the post-interview

Fig. 8 is related to the students' planning skills. In the first category, the students' goal-setting strategies before studying are shown. Ten students stated that they set their goals before studying science while two students stated that they didn't do so. When the students who stated that they set goals were asked about the kind of goals, the majority of them reported that they were eager to learn the subject. On the other hand, five students stated that they aimed to succeed and to use those skills and knowledge they learned in daily life. Four students stated that they aimed to be appreciated by the teachers and to take high marks on the exam. It is a positive finding that the students who stated that they had set their goals mentioned the content of their goals. This may indicate that their awareness levels of planning skills are increased. An example statement from the responses of the students is presented below.

"My main aim is to succeed in my lessons. My teachers support and encourage me to perform better, which I like a lot." (s_{10})

Another category in Fig. 8 is related to self-questioning before lesson. Eleven students stated that they asked themselves questions about the subjects to be taught in the science lessons while only one student stated otherwise. The students were asked to explain the content of the questions they ask themselves. The students mentioned what they were going to learn, how the subject was going to be learned and how they were going to benefit from learning it. Nine students questioned what they were going to learn, and seven students questioned how the subject was going to be learned, and six students questioned how they were going to benefit from learning it. It is an essential principle to plan wisely and put things into order to be successful. Asking such questions could indicate that they have acquired this skill. An example statement from the responses of the students is presented below.

"I usually ask myself about what I am going to learn and what kind of activities we are going to do before the lessons. Our lessons are enjoyable and full of different activities." (s_5)

In Fig. 8 the third category is related to arranging things to study science. Ten students stated that they made some arrangements to study while two students stated the contrary. Nine students stated that they reviewed the classroom activities during the lesson and created a study plan. Seven students stated that they revised the subjects learned in the lessons and created a study plan. It is crucially important for the students to create a study plan for them. The students who can organize what to do will have the ability to manage their learning. In this regard, the students can be seen to achieve this. An example statement from the responses of the students is presented below.

"I revise the subjects through the activities in the worksheets, thereby creating a study plan" (s_7)

Another category in Fig. 8 is related to the planning of time while studying. While eight students stated that they planned their time efficiently to study science, four students stated that they couldn't do so. Some students who stated that they planned their time efficiently when they were asked about what they did on the time management reported that they could prepare a study plan and stick to it. Some other students stated that they made plans according to the subject. Time management in planning skills is also very important to put things in order. Moreover, it can be suggested that the students' time management skills are well developed, which is a positive development. An example statement from the responses of the students is presented below.

"I think I am using my time efficiently. I have prepared a study plan and stick to it. I think I am studying hard enough to learn the subjects." (s_9)

3.3.1.2. The findings related to monitoring skills

The monitoring skill refers to the awareness of one's performance while performing a job. For example, it is related to the ability to test and monitor oneself in the process of learning (Schraw and Moshman, 1995). In pre- and post-interviews, some questions were asked about the monitoring skills of the students. Fig. 9 includes a model showing the categories and subcategories of the students' monitoring skills in the pre-interview. In this context, the frequency data were presented under three main categories created by the students' responses.

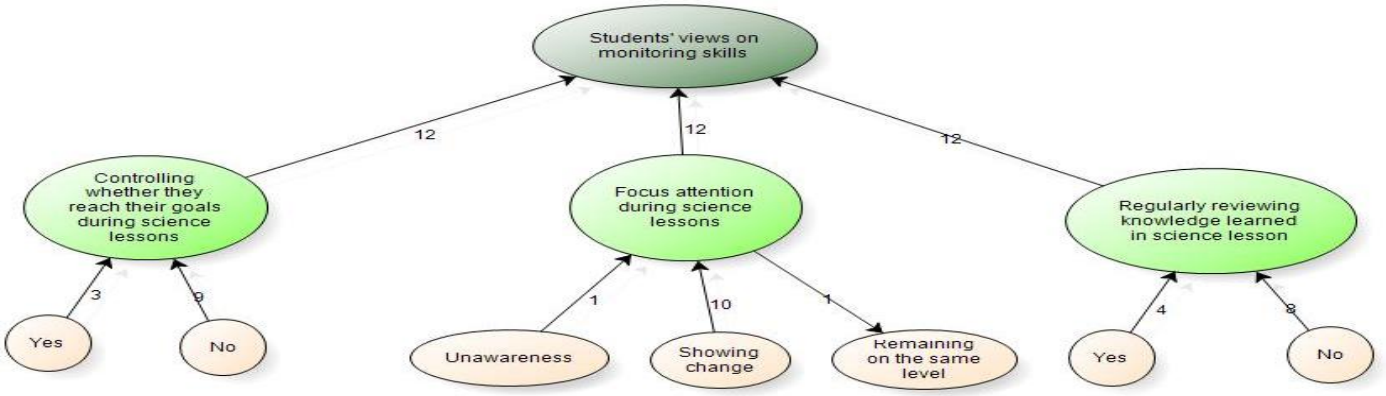

Figure 9. The model showing the categories and subcategories of the students' monitoring skills in the pre-interview

Considering the reaching goals category in Fig. 9, three students stated that they checked their goals during science lessons while nine students stated that they didn't do so. The three students were asked to provide information about how they check their goals, but they couldn't make any explanation. This may indicate that the students' ability to monitoring themselves during the course is not well developed. An example statement from the responses of the students is presented below.

"I didn't think about reaching my goals during the lessons." (s_6)

Another category in Fig. 9 is relevant to the attention span during the science lessons. One of the students stated that his/her attention level remained at the same level while ten students stated otherwise. These students stated that their attention was sometimes increased and decreased. However, they couldn't make any explanation for this shift in their attention. Another student stated that he/she is not aware of the level of attention. In this case, the changes in the attention observed during the lessons without any known reason may indicate that their level of awareness about themselves is low. An example statement from the responses of the students is presented below.

"I am occasionally distracted. But I am highly attentive in the lessons and don't know the reason for this case." (s_8)

The last category in Fig. 9 relates to regular review of learning during science lessons. When this category is examined, four students stated that they regularly reviewed the information to understand the subject in science courses. But they didn't explain how they did this. Eight students stated that they didn't review regularly. The findings may indicate that the students cannot question themselves in the course process. An example statement from the responses of the students is presented below.

"I sometimes care about what I am learning during the lesson." (s_7)

Fig. 10 includes the model showing the categories and subcategories of the monitoring skills in the post-interview. The frequencies are stated by creating categories within the framework of the answers they give. In this context, the frequency data were presented under four main categories created by the students' responses.

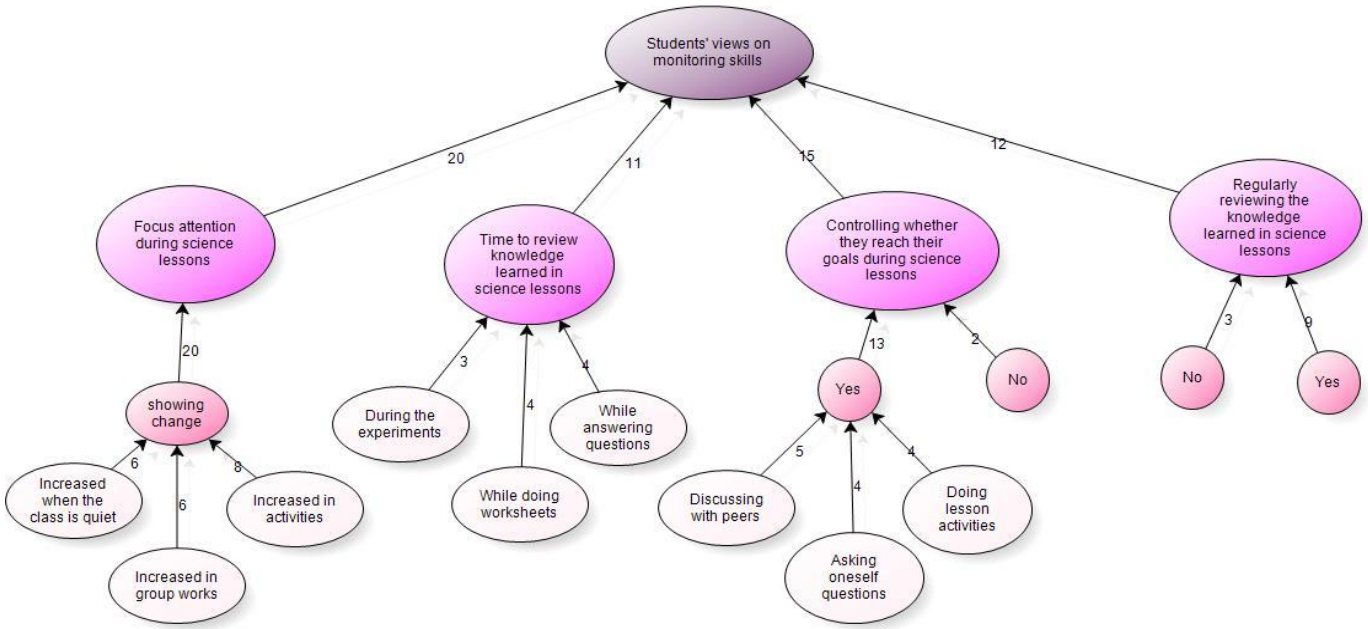

Figure 10. The model showing the categories and subcategories of the monitoring skills in the post-interview.

The first category in Fig. 10 is related to the students' control of reaching goals. Ten students stated that they questioned whether they reached their goals during the lessons. Two students stated the contrary. The students who stated that questioned were asked how they could control this. Five students stated that they checked through their discussions with their friends during the activities in the lessons. Again, four students mentioned that they checked their goals in this direction when performing activities. Finally, four students stated that they asked each other with their friends, and started questioning. In the process, it can be said that students have gained the ability to question themselves by monitoring their learning steps. An example statement from the responses of the students is presented below.

"Yes, I check whether I achieve my goals while performing activities in the lessons." (s_6)

The second category in Fig. 10 relates to the focus of attention in the lessons. When the figure is examined, it is observed that all students stated that their attention varied in the science lessons. When the reasons for this change to were asked by the students, this case arose from the classroom activities during the course and the general condition of the class. While eight students stated that their attention was increased while performing activities, six students stated that their attention was increased in the silence of the class and other six students stated that this occurred while working in groups. It can be said that external factors affect the students' learning. It will also enable students to realize the variables that affect them and take the necessary precautions. An example statement from the responses of the students is presented below.

"My attention is increased in group activities, which provides a lot of fun for me while learning." (s_4)

The other category in Fig. 10 relates to the regular review of the learning in the science lessons. When this category is examined, nine students stated that they regularly reviewed the learning that would help to understand the subject and three students didn't review. The students who responded positively were asked how and when they reviewed. These students stated that they reviewed their learning while they were studying on the worksheets, answering the questions, and doing some experiments. The next category is relevant to this. The fact that many of the students regularly review the subjects may show that they have acquired monitoring skills. An example statement from the responses of the students is presented below.

"Yes, I check and review my learning. I recognize that my previous learning is not enough." (s_9)

Another category of monitoring skills is related to the frequency of reviewing the subjects in the science lessons. The students who stated that they reviewed the subjects were asked in which stages they did so. Four students stated that they checked themselves while performing activities in the worksheets and answering the questions. Three students stated that they made reviews related to the experiments. The students knowing what to do in the lesson shows that they have developed good monitoring skills. An example statement from the responses of the students is presented below.

"I am continually thinking about the activities in the worksheets and revising the subjects" (s_2)

3.3.1.3. The findings related to evaluating skills

Evaluating skills refers to self-assessment of the one's learning process and its output (Schraw and Moshman, 1995). In pre- and post-interviews, some questions were asked to the students about their evaluating skills. Fig. 11 includes a model showing the categories and sub-categories of the students' evaluating skills in the pre-interview. In this context, the frequency data were presented under three main categories created by the students' responses.

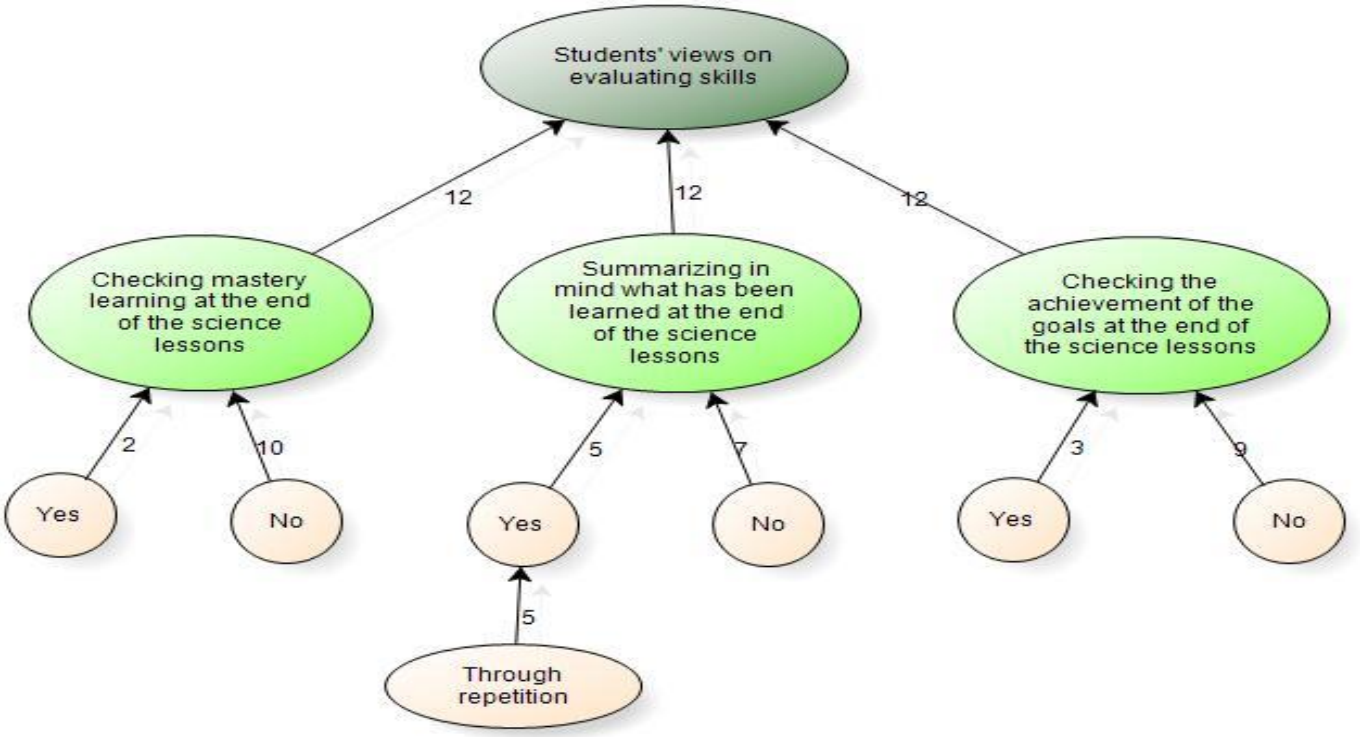

Figure 11. The model showing the categories and sub-categories of the students' evaluating skills in the pre-interview

Considering Fig. 11, in the category of summarizing the topics learned in the mind at the end of the lesson, five students stated that they summarized the topics at the end of the science lessons while seven students stated that they didn't do so. When they were asked about how they made a summary of topics, they emphasized repetition. The fact that the majority of the students didn't make a summary and those students who couldn't explain how they made a summary may indicate that they haven't developed good evaluating skills. An example statement from the responses of the students is presented below.

"I revise the topics after the lesson in a short period." (s_2)

Considering Fig. 11, in the category of checking the goal achievement, three students stated that they checked their goals after the lesson while nine students stated that they didn't do so. Although the students who stated that they checked their goals were asked how they did this, only one student could explain this case. In this regard, it can be argued that the students lack the skills to assess their performance at the end of the learning process. An example statement from the responses of the students is presented below.

"No, I don't check after the lesson. The exams are useful tools to do this." (s_6)

Considering Fig. 11, in the last category related to control of mastery learning after the subject is finished, two students stated that they controlled their mastery learning while ten students didn't do so. Although the students who stated that they controlled their mastery learning were asked how they did this, they didn't explain the case. In this context, mastery learning refers to what the students know or don't know. It is implied here that the students' self-assessment skills are low. An example statement from the responses of the students is presented below.

"Sometimes I control my learning process. When asked how to do it, I can' remember. Perhaps I ask myself some questions."(s_9)

Fig. 12 includes a model showing the categories and subcategories on the evaluating skills of the students in the post -interview. In this context, the frequency data were presented under four main categories created by the students' responses.

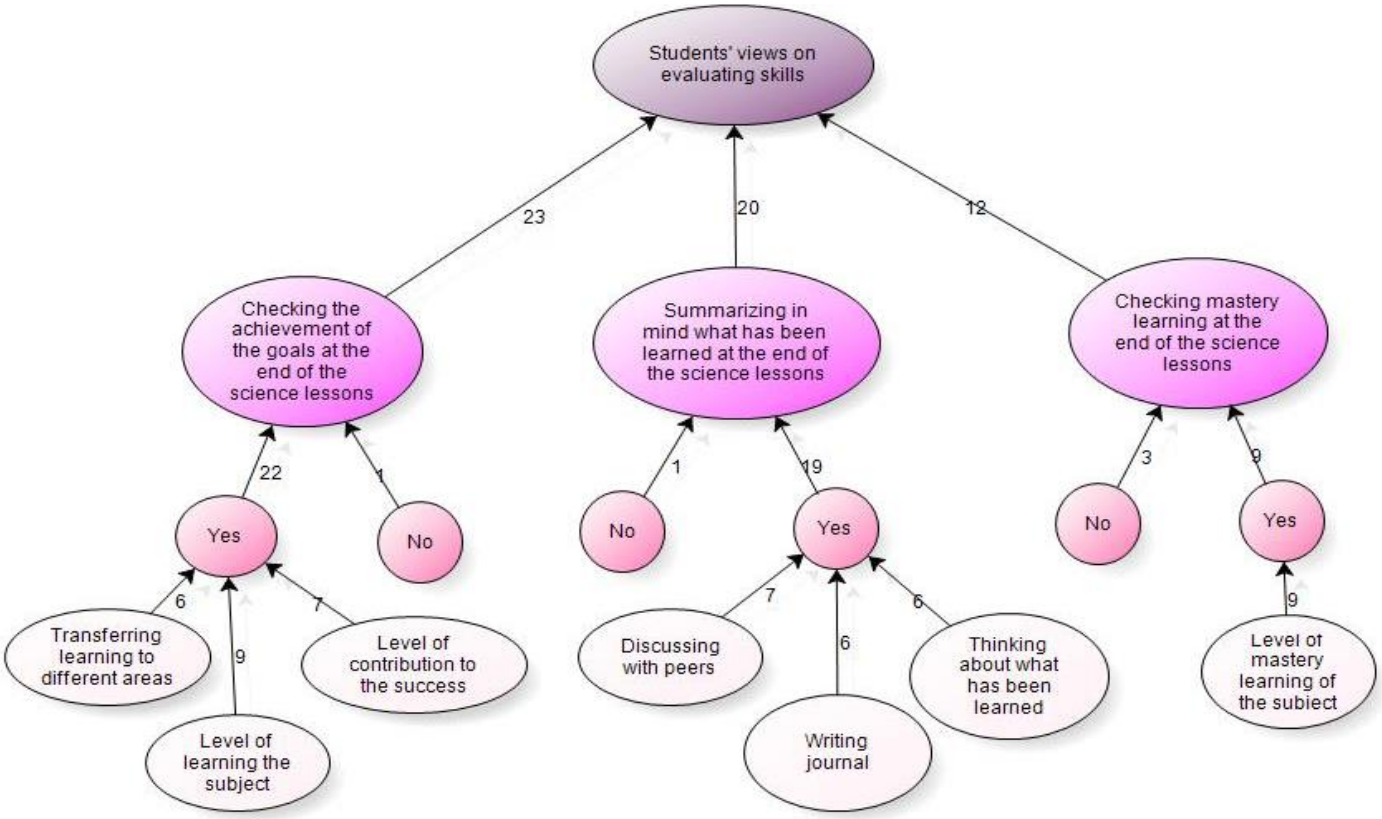

Figure 12. The model showing the categories and subcategories of the evaluating skills of the students in the post-interview

Considering Fig. 2, in the category of summarizing the topics learned in the mind at the end of the lesson, eleven students stated that they summarized what they learned at the end of the science lessons while only a student didn't do so. The students who made summaries were asked how to do this. Eight students stated that they thought about what they learned after the lesson. Seven students reported that they discussed the subjects at the end of the lesson while six students stated that they first made a summary and then wrote their journals. The students managed to observe the effectiveness of teaching themselves. An example statement from the responses of the students is presented below.

> *"Towards the end of the lesson, we have short and reflective discussions with friends, which makes the process efficient for me." (s_1)*

Considering Fig. 11, in the category of reaching the goals at the end of the science lessons, eleven students stated that they checked their goals after the lesson while only one student stated the contrary. Nine students cared about the learning level of the subject, seven students controlled the level of contributing to success, and six students checked whether they could use the learned skills in different areas. From these answers, it can be suggested that the students can evaluate themselves by focusing on their performance. At the same time, evaluating skills is important progress given transferring ideas to different areas because they include suggestions and corrections for subsequent learning experiences. An example statement from the responses of the students is presented below.

> *"My aim was just to learn the subject. Therefore, I check my learning at the end of the lesson and question my performance." (s_2)*

The last category in Fig. 12 is related to the control of mastery learning, eight students stated that they controlled themselves while four students didn't do so. The students who stated that they control themselves are in the majority. These students were also asked how they controlled this. The students stated that they compared them with their latest knowledge by thinking about what they knew about the subject in advance. They also stated that they thought about the activities in their minds and decided what their shortcomings were. This may indicate that the self-assessment skill, which is a requirement of the evaluating category, has been acquired by the students. An example statement from the responses of the students is presented below.

> *"I check myself after the lessons and question my learning, thereby assessing my learning process." (s_8)*

4. DISCUSSION AND CONCLUSION

About the students' metacognitive knowledge and regulation skills, based on the findings obtained from the MAI-C scale, a significant difference was found between the students' post-test scores whereas there was no significant difference between the pre-test scores of the experimental, control, and placebo group in terms of the level of metacognitive awareness. In addition,

the results of the pairwise comparisons test to determine differences across the groups it was found that the experimental-control, and experimental-placebo groups were significantly different, but there was no significant difference between the post-test scores of the control-placebo groups. In the light of these quantitative findings, it can be suggested that formative assessment practices are effective in the metacognitive awareness of the students in the experimental group.

When the qualitative findings were examined, there were similar findings to the quantitative findings. In the pre-interviews with the experimental group before the experimental procedure, the students' declarative, procedural, and conditional knowledge levels were insufficient however, it was revealed that there was significant progress in the post-interviews. Likewise, while the planning, monitoring, and evaluating categories of metacognitive regulation skills were not sufficient in the pre-interview, it was observed that there was significant progress in these skills in the post-interviews. Notable in these findings is that the students aimed to succeed in exams rather than learn the subjects by memorization in the pre-interviews. However, in the post-interviews, contrary to this case, the students mentioned the concepts of learning, understanding, and regulating learning. It has been emphasized in many studies that there is a relationship between the different types of assessment used in the teaching process and the metacognitive skills of the students (Andrade, 1999; Braund and Deluca, 2018; Broadbent et al., 2021; Durmuş, 2013; Fukuda et al., 2020; Granberg, Palm & Palmberg, 2021; Hudesman et al., 2013; Molin et al., 2020; Wang, 2020). Wannus and Sulieman (2021) examined the effects of teachers' knowledge about formative assessment practices on their practices and students' metacognitive skills. As a result of the examination of the ten different studies in which the effect of formative assessment and learning/teaching was investigated, they found that teachers' knowledge of the formative assessment is effective in their teaching practices and supports the metacognitive awareness of the students. In one of the experimental studies where the relationship between the assessment process and metacognition was examined, Molin et al. (2020) concluded that peer discussions combined with teacher feedback as a formative assessment had an impact on the metacognitive awareness of the students. In another study Andrade (1999) examined student self-assessments at the intersection of metacognition and authentic assessment. In the study conducted with 47 students, the pre-test and post-test control groups were investigated by using scales on an experimental design. The results of the study revealed that self-assessment activities were effective in the development of female students' metacognitive skills. In parallel with the results of Andrade's study (1999), it was also found that the metacognitive skills of the students were affected by the assessment activities. In addition, in line with the study, as a result of the findings obtained from the qualitative analysis, the assessment and self-control skills of the students were observed to be developed. In another experimental study Durmuş (2013) investigated the relationship between multiple intelligence theory and the use of alternative assessment techniques in teaching with the metacognitive skills. The study was conducted among 120 students in the sixth grade with an experimental design with pre-test and post-test control groups. It was revealed that the experimental process carried out with alternative assessment improved students' metacognitive skills. Similar to this study, Taşkın and Çakmak (2017) used gamification activities as an alternative assessment technique and examine the effect of alternative assessment on the metacognitive awareness of students. As a result, they concluded that these activities positively affected the metacognitive skills. Similar to the procedures conducted in this study, different alternative assessment techniques were used in the teaching process. Based on the quantitative data, it was determined that the metacognitive skills of the students were positively affected by the practices in the process. In addition, in the interviews held within the scope of qualitative research, it was found that the students mentioned the benefits of alternative assessment techniques used in their response to the teaching practices. In another study conducted for similar purposes, Braund and Deluca (2018) aimed to determine how teachers benefited from formative assessments in teaching metacognitive and self-regulation skills. The study was carried out with 44 teachers based on the sequential mixed method. The results of the study indicated that formative assessment practices were associated with metacognitive skills. In addition, participants stated that self-assessment, peer assessment, and reflective thinking practices improved the metacognitive skills of the students similarly, according to the qualitative data obtained in this study, the students expressed that their self-regulation and reflective thinking skills improved. This showed positive developments for planning, monitoring and evaluating dimensions in the regulation of metacognitive skills. In addition, in this study, it is understood from the statements of the students in the interviews that self-assessment and peer assessments which are the alternative assessment techniques used in the formative assessment process are effective on the metacognitive skills of the students. Similarly, Hudesman et al. (2013) carried out a study to increase the role of formative assessment and the role of metacognition in increasing students' success. In the study, a teaching model was prepared by combining self-regulation and an enhanced formative assessment program. This model was used in a college for three years in various periods. It was stated that the metacognitive skills of the group where the program was applied increased, the students performed better success and transferred their learning to the next educational levels. In this study, in parallel with that, it was found that the formative assessment practices developed metacognitive skills.

In conclusion, the practices of formative assessment in the science courses were found to be effective in the ability to organize the metacognitive knowledge and regulation skills. It is recommended that these practices and alternative assessment techniques should be more widely used in science courses. This study has been limited to examining the effects of different assessment types on metacognitive knowledge and metacognitive regulation skills. In future studies, it may be recommended to conduct research on different teaching interventions that may affect metacognition. Another limitation of this study is that it was carried out with 37 students studying in the seventh grade. Since this study was conducted with a limited group in terms of both sample size and class level, future studies covering different class levels and sample sizes can be conducted. In particular, in the national literature of this field, it is recommended to increase the number of studies since there is limited number of studies.

Research and Publication Ethics Statement

In this study, all the rules specified to be followed within the scope of the "Higher Education Institutions Scientific Research and Publication Ethics Directive" were complied with. None of the actions specified under the title of "Actions Contrary to Scientific Research and Publication Ethics", which is the second part of the directive, were not carried out.

Contribution Rates of Authors to the Article

This study is a part of first authors' master thesis, supervised by 2nd author. The researchers contributed equally to the study.

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Statement of Interest

There is no conflict of interest between the authors or with any institution or organization.

5. REFERENCES

Açıkgöz, K.Ü. (2000). *Etkili öğrenme ve öğretme* (Üçüncü Baskı). İzmir: Kanyılmaz Matbaası.

Ames, C. (1992). Classrooms: Goals structures and student motivation. *Journal of Educational Psychology, 84*(3), 261–271.

Andrade, H. G. (1999). *Student self-assessment: At the intersection of authentic assessment.* Paper Presented at the Annual Meeting of the American Educational Research Association, April 19-23, Montreal, Quebec, Canada.

Baas, D., Castelijns, J., Vermeulen, M., Martens, R., & Segers, M. (2015). The relation between Assessment for Learning and elementary students' cognitive and metacognitive strategy use. *British Journal of Educational Psychology, 85*(1), 33-46.

Bayrak, N., Çalık, M., ve Doğan, S. (2021). Akıllı biçimlendirici değerlendirme sisteminin akademik başarı ve ders sürecine etkisi. *Hacettepe Üniversitesi Eğitim Fakültesi Dergisi. 36*(2), 333-349.

Baysal, Z. N. ve Demirbaş, B. (2012). Sınıf öğretmenliği adaylarının bilinçli farkındalıkları ile yansıtıcı düşünme eğilimleri arasındaki ilişkinin incelenmesi. *Eğitim ve Öğretim Araştırmaları Dergisi, 1*(4), 12-20.

Black, P. & William, D. (1998). Assessment and classroom learning. *Assessment in Education: Principles, Policy, and Practice, 5*(1), 7-74.

Blakey, E. & Spence, S. (1990). *Developing metacognition*. Retrieved from https://files.eric.ed.gov/fulltext/ED327218.pdf.

Block, C. C. (2004). *Teaching comprehension: The comprehension process approach.* Boston: Allyn and Bacon.

Boekaerts, M. E. (1999). Self-regulated learning: Where we are today. *International Journal of Educational Research, 31(*6), 445-457.

Braund, H. & DeLuca, C. (2018). Elementary students as active agents in their learning: an empirical study of the connections between assessment practices and student metacognition. *The Australian Educational Researcher, 45*(1), 65-85.

Broadbent, J., Sharman, S., Panadero, E., & Fuller-Tyszkiewicz, M. (2021). How does self-regulated learning influence formative assessment and summative grade? Comparing online and blended learners. *The Internet and Higher Education, 50*, 100805.

Brookhart, S. M. (1997). A theoretical framework for the role of classroom assessment in motivating student effort and achievement. *Applied Measurement in Education, 10*(2), 161 – 180.

Buldur, S. (2014). *Performansa dayalı tekniklerle yürütülen biçimlendirmeye yönelik değerlendirme sürecinin öğretmen ve öğrenci üzerindeki etkisi.* Yayımlanmamış Doktora Tezi, Gazi Üniversitesi Eğitim Bilimleri Enstitüsü, Ankara.

Buldur, S., ve Doğan, A. (2017). Performansa dayalı tekniklerle yürütülen biçimlendirmeye yönelik değerlendirme sürecinin öğrencilerin hedef yönelimlerine etkisi. *Hacettepe Üniversitesi Eğitim Fakültesi Dergisi, 32*(1), 143-167.

Büyüköztürk, Ş. (2001). *Deneysel desenler.* Ankara: Pegem A Yayıncılık.

Cauley, K. M. & McMillan, J. H. (2010). *Formative assessment techniques to support student motivation and achievement*. *The Clearing House: A Journal of Educational Strategies, Issues and Ideas*, *83*(1), 1-6.

Creswell, J. W. (2005). *Educational research: planning, conducting, and evaluating quantitative and qualitative research* (2nd ed.). Upper Saddle River, New Jersey, Pearson Education, Inc.

Creswell, J.W. & Plano-Clark, V.L. (2011). *Designing and conducting mixed methods research. California: Sage Publications.*

Çakıcı, Y. (2008). Fen ve teknoloji öğretiminde yapılandırmacı yaklaşım. Ö. Taşkın (Edt.). *Fen ve teknoloji öğretiminde yeni yaklaşımlar*, (2-19). Ankara: Pegem A.

Çakıroğlu, A. (2007). Üstbiliş. *Türkiye Sosyal Araştırmalar Dergisi, 11*(2), 22-27.

Çepni, S. ve Ayvacı, H. Ş. (2007). Fen ve teknoloji eğitiminde alternatif (performans) değerlendirme yaklaşımları. S. Çepni (Edt.). *Kuramdan uygulamaya fen ve teknoloji öğretimi,* (269- 284). Ankara: Pegem A.

Demir, Ö. ve Doğanay, A. (2009). Bilişsel farkındalık becerilerinin geliştirilmesinde bilişsel koçluk yaklaşımı. *Kuram ve Uygulamada Eğitim Yönetimi, 15*(4), 601-624.

Demircioğlu, H. (2008). *Matematik öğretmen adaylarının üst bilişsel davranışlarının gelişimine yönelik tasarlanan eğitim durumlarının etkililiği.* Yayımlanmamış Doktora Tezi, Gazi Üniversitesi Eğitim Bilimleri Enstitüsü, Ankara.

Durmuş, L. (2013). 8. *sınıf öğrencilerinin problem çözme sürecinde kullandığı üst biliş becerilerin incelenmesi.* Yayımlanmamış Yüksek Lisans Tezi, Karadeniz Teknik Üniversitesi Fen Bilimleri Enstitüsü, Trabzon.

Flavell, J. H. (1987). Speculations about the nature and development of metacognition. In F.E. Weinert and R.H. Kluwe (Eds.), *Metacognition, motivation and understanding.* Hillsdale, NJ: Lawrence Erlbaum Associates, Publishers.

Fukuda, S. T., Lander, B. W., & Pope, C. J. (2020). Formative assessment for learning how to learn: exploring university student learning experiences. *RELC Journal,* 1-16.

Granberg, C., Palm, T., & Palmberg, B. (2021). A case study of a formative assessment practice and the effects on students' self-regulated learning. *Studies in Educational Evaluation, 68, 100955.*

Gunstone, R.F. & Mitchell, I.J. (1998). Metacognition and Conceptual Change. In J.J. Mintzes, J.H. Wandersee and J.D. Novak (Eds) *Teaching Science for Understanding:* A Human Constructivist View (133-163). San Diego: Academic Press.

Hattie, J. & Timperley, H. (2007). The power of feedback. *Review of Educational Research, 77*(1), 81-112.

Hudesman, J., Crosby, S., Flugman, B., Issac, S., Everson, H., & Clay, D. B. (2013). Using formative assessment and metacognition to improve student achievement. *Journal of Developmental Education, 37*(1), 2-13.

Jacobs, J. E. & Paris, S. G. (1987). Children's metacognition about reading: Issues in definition, measurement, and instruction. *Educational Psychologist, 22*, 255-278.

Jones, D. (2007). Speaking, listening, planning and assessing: The teacher's role in developing metacognitive awareness. *Early Child Development and Care. 177*(6-7), 569-579.

Karakelle, S. ve Saraç, S. (2007). Çocuklar için üst bilişsel farkındalık ölçeği (ÜBFÖ-Ç) A ve B formları: Geçerlik ve güvenirlik çalışması. *Türk Psikoloji Yazıları, 10(20),* 87-103.

Keeley, P. (2008). *Science formative assessment: 75 practical strategies for linking assessment, ınstruction, and learning*. California: Corwin and NSTA Press.

Kirk, J. & Miller, M. L. (1986). *Reliability and validity in qualitative research*. A Sage: University Paper.

Kocakaya, S. (2011). An educational dilemma: Are educational experiments working? *Educational Research and Reviews, 6*(1), 110-123.

Kocakaya, S. (2012). Deneysel araştırmalar ne kadar güvenilir? *Journal of Research in Education and Teaching, 1*(2), 225-231.

LeCompte, M. D. & Goetz, J. P. (1982). Problems of reliability and validity in ethnographic research. *Review of Educational Research*, *52*(1), 31-60.

Linn, R. (1990). Essentials of student assessment: from accountability to instructional aid. *Teachers College Record, 91*(3), 422–436.

Maslovaty, N. & Kuzi, E. (2002). Promoting motivational goals through alternative or traditional assessment. *Studies in Educational Evaluation, 28*(3), 199 – 222.

Molin, F., Haelermans, C., Cabus, S., & Groot, W. (2020). The effect of feedback on metacognition-a randomized experiment using polling technology. *Computers & Education, 152*, 103885.

Miller, M., Linn, R., & Gronlund, N. (2009). *Measurement and assessment in teaching.* Upper Saddle River,NJ: Pearson.

Pintrich, P., Smith D., Garcia T., & McKeachie W. (1991). *A manual for the use of the motivated strategies for learning questionnaire*. Retrieved from https://files.eric.ed.gov/fulltext/ED338122.pdf.

Popham, W. J. (2008). *Transformative assessment*. Alexandria, VA: Association for Supervision and Curriculum Development.

Senemoğlu, N. (2004). *Gelişim, öğrenme ve öğretim: kuramdan uygulamaya*. Ankara: Gazi Kitabevi.

Schraw, G., Crippen, K. J., & Hartley, K. (2006). Promoting self-regulation in science education: Metacognition as part of a broader perspective on learning. *Research in Science Education, 36*, 111-139.

Schraw, G. & Moshman, D. (1995). Metacognitive theories. *Educational Psychological Review, 7*, 351-371.

Shepard, L. A. (1989). Why we need better assessment? *Educational Leadership, 46*(7), 4-9.

Shepard, L. A. (2019). Classroom assessment to support teaching and learning. *The ANNALS of the American Academy of Political and Social Science, 683*(1), 183-200.

Sperling, R. A., Howard, B. C., Miller, L. A., & Murphy, C. (2002). Measures of children's knowledge and regulation of cognition. *Contemporary Educational Psychology, 27(1),* 51-79.

Struyven, K, Dochy, F., & Janssens, S. (2005). Students' perceptions about evaluation and assessment in higher education: A review. *Assessment and Evaluation in Higher Education, 30*(4), 325-341.

Taşkın, N. ve Çakmak, E. K. (2017). Öğrenci merkezli öğrenme ortamlarında oyunlaştırmanın alternatif değerlendirme amaçlı kullanımı. *Bartın Üniversitesi Eğitim Fakültesi Dergisi*, *6*(3), 1227-1248.

Wafubwa, R. N., & Csíkos, C. (2021). Formative assessment as a predictor of mathematics teachers' levels of metacognitive regulation. *International Journal of Instruction, 14*(1), 983-998.

Wang, C. Y. (2015). Exploring general versus task-specific assessments of metacognition in university chemistry students: a multitrait–multimethod analysis. *Research in Science Education*, *45*(4), 555-579.

Wang, J. (2020). Exploring the perceived ıntegrations between assessment and metacognition: a qualitative ınquiry of three award-winning teacher educators' conceptions of assessment in a Hong Kong university context. *Frontiers in Education, 4,* (157), 1-15.

Wannus, A. & Sulieman, N. (2021). Effects of teachers' knowledge of formative assessment on teachers' practices & students' metacognition: A literature review. Retrieved from https://www.diva-portal.org/smash/record.jsf?pid=diva2%3A1562768&dswid=-4476.

Yurdabakan, İ. (2011). Yapılandırmacı kuramın değerlendirmeye bakışı: eğitimde alternatif değerlendirme yöntemleri. *Ankara Üniversitesi Eğitim Bilimleri Fakültesi Dergisi, 44*(1), 51-77.

Zimmerman, B. J. (2000). Attaining self-regulation: A social cognitive perspective. In M. Boekaerts, P. Pintrich & M. Zeidner (Eds.), *Self-regulation: Theory, research and applications* (pp. 13-39). Orlando, FL: Academic.