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Research Article

Investigation of Metacognitive Strategy Tendencies of Students in Science Course within the Scope of Support and Training Courses

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Abstract –Support and training courses (STCs) within the scope of non-formal education, it is aimed to increase students' course success; however, the direction in which students' perceptions of motivational components change in this process is not taken into account. The present study is dedicated to examining the longitudinal trends of students' perceptions of metacognitive learning strategies (MLS) within the context of science lessons during the summer term. A total of 622 students (51.6% female; 48.4% male) from four different secondary schools were involved in the research, which utilized the relational screening model. The findings indicate a significant longitudinal increase in students' tendencies to use MLS. Additionally, the intergroup analysis comparing female and male students revealed no significant difference in MLS scores between the two groups. The rise in students' MLS scores without any instructional intervention indicates that choice-based STCs increase students' active engagement in learning tasks and encourages motivational processes related to the course. This underscores students' active control of cognitive strategies during learning and upon completion of tasks. The results show that students need to benefit more from non-formal and informal learning environments for science classes. Expanding the inclusiveness of STCs by including students with high learning losses, declining interest in science courses, and socioeconomic disadvantages may increase homogeneity among students regarding academic competencies. Therefore, policymakers should consider integrating metacognition and associated learning strategies into routine science education by devising processes that facilitate this integration in curricula and teacher education.

Keywords: Metacognition, out-of-school education, science education, science teaching, middle school students.

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Introduction

In the changing world and working life, the knowledge and skills, values, and attitudes that need to adapt to intercultural contexts have led to multidimensional competencies gaining more space in education plans and policies (Organization for Economic Cooperation and Development [OECD], 2018a). In education, science lessons have become a part of social goals, beyond the demands of developing technology and a scientifically qualified workforce, consistent with the predictions of international competencies. One of the most important developments in learning sciences that has significantly influenced science education research is the transition from seeing learning as an individual process to understanding that knowledge and knowing are situated in social and cultural contexts (Pellegrino, 2020). In parallel, science education today is evolving towards producing a new generation of citizens who are scientifically literate and thus better prepared to function in a world increasingly influenced by science and technology.

Science courses are critical in meeting the needs of 21st-century competencies that are expected to be indispensable in the changing world and working life in the future. Indeed, in today's world where access to information is accelerating, individuals are expected to be able to organize and use the information they have accessed and reflect it in multiple tasks. The global competencies and basic skills represented in the lists of 21st-century competencies intersect with the basic principles and ideas of science education that people need to understand and apply in different areas (Voogt & Roblin, 2012). Thuneberg et al. (2022) emphasize seven competence areas, emphasizing the importance of viewing these competences as overarching principles guiding subject-specific teaching. These areas include: (a) learning to think and learn, (b) cultural competence, (c) daily life management competence, (d) multiliteracy, (e) information and communication technology competence, (f) work-life competence, and (g) participation, inclusion and sustainability. In parallel with this, in our country, it is emphasized in the core curriculum (framework curriculum) that it is necessary to encourage students' multifaceted scientific literacy in science education (Ministry of National Education-MoNE, 2024). It can be said that the basic objectives on which the curriculum in practice in our country is based include elements such as cognitive abilities, personal attitudes, communication skills, social values, social skills, and dimensions of self-efficacy. These objectives do not specifically target any subject discipline; they are expected to be acquired as a whole during the education process. The specific objectives in the science curriculum are listed as field-specific skills (a) scientific process skills, (b) life skills (analytical thinking, decision making, creative thinking, entrepreneurship, communication, and teamwork), and (c) engineering and design skills (MoNE, 2018). The objectives in the science curriculum, unlike the general objectives of education, require a context, and this context inevitably includes science content and conceptual structuring related to the science course.

In a world that is becoming increasingly interconnected, where economic productivity and educational achievement are closely linked and competitive, there is a growing emphasis on standards-based science education (DeBoer, 2011). The "OECD Learning Framework 2030" (OECD, 2018b), which is a pioneer of this trend and is effective in setting new criteria and targets in curriculum standards, creates significant changes in the curriculum reforms of various countries. Many countries are redoubling their efforts to establish higher standards in order to maintain a competitive edge in the global arena and achieve their desired educational objectives. The driving forces behind this global movement are the Programme for International Student Assessment (PISA), the Trends in International Mathematics and Science Survey (TIMSS), and the associated student performance reports, which shed light on the relative performance of students worldwide. The results of both PISA and TIMSS serve as crucial tools for policymakers to consider when seeking to enhance science education within their respective nations. Simultaneously, as noted by Apple (2000) and Carter (2005), these results also provide opportunities for increased accountability, oversight, and regulation.

The impact of student success in science courses under the STEM umbrella on future science courses and career choices is a significant consideration (Ainley & Ainley, 2011; Vedder-Weiss & Fortus, 2018). Science education is increasingly important on national and international levels, but there are several issues that affect students' success, perceptions, and practices in science education. One of these concerns is the use and effectiveness of textbooks. To help students learn, countries need to develop high-quality teaching materials or textbooks that are aligned with curriculum standards. Textbooks that lack personal interest and appeal to students can make it harder to achieve the intended outcomes. In particular, due to the abstract concepts and scientific language in science textbooks, science may be perceived as boring for students. Indeed, Li and Wang (2024) and Harris et al. (2014) argue that the use of high-quality teaching materials can improve students' performance in science.

Another issue that effects science learning is related to teacher competence. In a review focusing on learning sciences and science education research (Songer & Kali, 2022), it is reported that current teacher competence is incompatible with today's knowledge-based and innovative society and is increasingly criticized. Teachers are often considered the primary source of knowledge and are responsible for conveying content to students (Jesaani, 2015). However, public exams, such as the high school entrance exam, can limit the freedom and authority of teachers in choosing and presenting content, putting pressure on them to cover all the content in a limited time at the expense of students' learning. The successful implementation of science education reforms in Türkiye is contingent on addressing various challenges at the policy and implementation levels. One of these steps is the establishment of support and training courses (STCs) financed by the government and associated with out-of-school learning. Launched by the Ministry of National Education in the 2014-2015 academic year, STCs aims to enhance the academic achievement of secondary and high school students. These non-formal learning environments offer structured course activities based on student participation and course selection, fostering an environment for holistic development and interaction with peers.

Out-of-school learning encompasses various activities in different open learning environments, such as museums, nature parks, art exhibitions, aquariums, science centers, accommodation and offer integrative pedagogy opportunities to achieve targeted outcomes. Out-of-school learning can be designed as a summer school to improve academic skills and reduce learning losses, or it can have appearances that include enriched options and support the development of students' skills in language, art and sports (Koop, 2010). STC applications carried out in our country mostly consist of accelerated contents that complement the gains foreseen in official programs. However, since STCs offers students the opportunity to choose courses freely, it has some similarities with the learning activities referred to as out-of-school learning in the literature. For example, according to the MoNE (2024) STCs directive, students can apply for courses in certain fields (e.g., mathematics, science, Turkish), as well as courses such as sports, music and visual arts within the scope of summer school courses. Conversely, the fact that the activities envisaged by STCs are carried out in schools or course centers suggests a lack of real-life experiences that can be triggered in different learning contexts.

Previous studies on STCs have primarily explored teachers' attitudes towards courses (Aküzüm & Saraçoğlu, 2018), teachers' perspectives on challenges encountered in courses (Bozbayındır & Kara, 2017; Sarıca, 2018), and students' viewpoints (Çağrı Biber et al., 2017; İncirci et al., 2017). However, there is a noticeable gap in the research regarding the changes in students' perceived motivational processes towards science learning in the STC process over time. The cognitive and motivational processes experienced by students in this context are equally significant as the STCs practices and encountered difficulties. Because, research (e.g., Thuneberg et al., 2022) has shown that out-of-school learning activities encourage students to develop confidence in their own abilities, abstract thinking, complex reasoning, and promote metacognitive learning that reflects learner autonomy. Bannert et al. (2015) found that students achieved positive results by using their metacognitive prompts in computer-based learning environments without any instructional intervention. With the updated science curriculum placing greater emphasis on integrating conceptual knowledge with real-world experiences and learning from informal and non-formal environments, it is essential to investigate how students' motivational perceptions in these settings have evolved. On the other hand, it is emphasized in the literature that middle school students' motivation to learn science decreases as their grade levels advance (Liou et al., 2020). Therefore, examining motivation, a crucial factor in students' engagement with learning tasks, and its underlying mechanisms in science learning environments within the framework of STC is crucial for achieving the expected educational outcomes.

The influence of metacognition, a motivational factor, on the process of learning and teaching has emerged as a focal point in educational research. Metacognition pertains to the mechanisms involved in acquiring the ability to learn (Flavell, 1979). Flavell et al. (2002) differentiate between two essential constituents of metacognition: metacognitive knowledge and metacognitive self-regulation. Whitebread et al. (2009) further expound on the metacognitive elements, delineating them as planning (the selection of strategies and procedures and the endeavor to employ them in tackling the present problem), monitoring (sustained awareness of task performance and the attainment of desired goals), evaluation (appraisal of learning processes and learning outcomes), and self-regulation/control (management of cognitive activities during learning). This study has embraced the self-regulation aspect of metacognition, which encompasses the abilities and processes employed to steer, control, and regulate cognition and learning, in line with the conceptualizations of Flavell et al. (2002) and Whitebread et al. (2009). The strategies encapsulated by metacognition pertain to the processes of reasoning, learning, and problem-solving. Metacognitive learning strategies entail individuals actively overseeing and regulating cognitive strategies during and after the learning process (Magaji & Umar, 2016). Metacognitive learning strategies are essential for students to achieve their academic goals. These strategies, encompassing thinking, learning, and problem-solving approaches, have been linked to improved performance (Fooladvand et al., 2017; Zohar & Barzilai, 2013). Previous research has highlighted the positive correlation between the use of metacognitive learning strategies and motivation (Atay, 2014; Rashid & Rana, 2019). Furthermore, the literature underscores the significance of these strategies in students' academic progress (Afrashteh & Rezaei, 2022; Teng, 2020; Xiao & Zhao, 2024). Winne and Azevedo (2014) emphasized that metacognition plays an important role in all cognitive tasks and should be integrated in science education practices. Considering the importance of metacognition for learning environments, it follows that students should be encouraged to use these strategies.

The literature predominantly focuses on investigating metacognitive learning strategies (MLS) and their correlation with motivation among students in formal educational settings. However, there is a dearth of research exploring the motivational processes experienced by students during informal learning activities, such as STCs, which are characterized by student autonomy and are conducted outside the formal education environment. Recognizing this research gap, the present study aims to longitudinally examine students' perceptions of metacognitive learning strategies in the context of science lessons during the summer term STC. Longitudinal data collection is crucial for evaluating hypotheses that cannot be adequately addressed with only cross-sectional or dichotomous data (Preacher et al., 2008). Given that data will be gathered at three different time points, it is important to acknowledge the potential emergence of complex relationships. Therefore, efforts have been made to delineate the directionality of the effects based on prior research findings in order to mitigate this complexity.

Another rationale that guided this research was that administrators, teachers, and parents viewed STCs as a way to motivate students and prevent student achievement from declining. Although practices integrated with curricula are implemented in short-term course environments in Türkiye, the learning experience created by these practices differs from the formal education context. Expecting long-term educational outcomes, which are associated with formal education, from STCs may lead to inaccurate conclusions due to their short-term nature. Therefore, it is critical to enrich the understanding of the effects of the STCs context on students' cognitive appraisals, motivational perceptions, and academic outcomes. It is expected that the results of the current study will inform future studies to improve science teaching practices and will also encourage studies to increase the effectiveness of out-of-school learning contexts.

Purpose of the Study

The aim of this study is to analyze the long-term trends in summer term STC students' perceptions of MLS in science lessons. To achieve this, we have formulated the following questions:

- How do summer term STC students' perceptions of learning strategies in science lessons change over time, and to what extent?
- Do the changes in students' perceptions of learning strategies in science lessons within the scope of STC differ between male and female students over time?

Methods

Research Model

This research was conducted based on the relational screening model because it makes it possible to reach the opinions of large masses. According to Karasar (2005), in relational screening models, differences between groups are examined according to the status of the determined variables. In this model, there is a possibility that the data may not reflect the participants' genuine views or may mislead the participants by making them state an opinion that aligns closely with their own (Fraenkel & Wallen, 2006).

Population and Sample

The study encompasses all students enrolled in science courses within the framework of STC at secondary schools in the Artuklu district of Mardin province during the 2022-2023 academic year. The sample for the study was drawn from students studying science courses within the scope of STC at 4 secondary schools. The selection of schools for the study was guided by criterion sampling, a purposeful sampling method. According to Patton (2002), purposeful sampling allows for a detailed examination of situations containing comprehensive information. Criterion sampling involves the examination of events and facts that meet specific criteria determined by the researcher (Yıldırım & Şimşek, 2013). The criteria for selecting the sample for this study are as follows: enrollment in secondary school and attendance in the 8^{th}-grade science course within the scope of STC summer courses. To estimate the minimum sample size, an a priori power analysis was conducted using G*Power version 3.1.9.7 (Faul et al., 2007). The results indicated that with a significance level of α = .05, the sample size required to obtain a medium effect and achieve power at the .95 level was $N = 42$. Therefore, it can be said that the sample gathered for this study reflects the ratio required by the recommended sample size. Descriptive information about the sample is provided in Table 1.

Table 1 Participant Characteristics

Variables	T1		T2		T3	
	n	%	n	%	n	%
Gender						
Female	321	51.6	310	51.2	308	51.8
Male	301	48.4	295	48.8	287	48.2
School						
1st school	142	22.8	141	23.3	139	23.4
2nd school	150	24.1	148	24.5	143	24.0
3rd school	151	24.3	145	24.0	140	23.5
4th school	179	28.8	171	28.2	173	29.1
Total	622	100.0	605	100.0	595	100.0

According to Table 1, 622 individuals (321 females [51.6%], 301 males [48.4%]) participated in the study at time point T1, 605 individuals (310 females [51.2%], 295 males [48.8%]) at time point T2, and 595 individuals (308 females [51.8%], 287 males [48.2%]) at time point T3. When the student distribution across schools was examined between time points T1 and T3, 139-142 students participated from the first school, 143-150 students from the second school, 140-151 students from the third school, and 173-179 students from the fourth school. At time point T1, 622 students completed the scales, at time point T2, 605 students completed the scales, and at time point T3, 595 students completed the scales. The final sample size analyzed was 95% (595/622). Therefore, there was a 5% loss of participants. The age range of the participants spanned from 13 to 16 years, with an average age of 14.01 years (standard deviation = 3.33).

Procedure

The data collection process commenced following the approval of the Fırat University ethics committee (ethics committee reference number: 2022/9684) and the authorization of the provincial directorate of national education. The research was guided by ethical principles set out by the British Psychological Society (2021), including: (a) respect, (b) competence, (c) responsibility and (d) integrity. Prior to participating in the study, students were required to obtain parental consent and participant approval. It was clearly communicated to the students that they had the option to abstain from responding to the surveys without facing any repercussions at any stage before, during, or after the data collection. Students were informed that their data would be anonymous. The traditional paper and pencil data collection method was implemented during regular course hours. The surveys were administered during nonscience class hours to minimize potential teacher and student expectation biases. Prior to commencing the survey, the researcher provided participants with detailed information regarding the study's objectives and procedures. Participants were explicitly informed that the surveys did not pertain to their personal preferences regarding their teachers or their general teaching styles. Instead, participants were asked to evaluate each statement independently based on its content and context. Throughout the questionnaire completion process, students were encouraged to signal at any time and silently ask questions if they encountered difficulties in understanding the items. The three data collection phases (see Figure 1) were conducted in the first week of the STCs (July), the first week of August, and the last week of August. Each survey took approximately 10 minutes for students to complete. The first step of data collection (week one) was carried out at the beginning of the STC sessions. In the first week, data were collected before the presentation of the course content began. In this way, the possible effects of the STC process on the students' cognitive processes were tried to be reduced. The second step of data collection coincided with the fifth week of the course calendar. In the process until this week of the accelerated course program, students had covered four of the seven units in the course program. The last measurement was carried out in the eighth week, after the end of the course. Thus, the effects of STC on the students' MLS levels were measured longitudinally through three consecutive measurements.

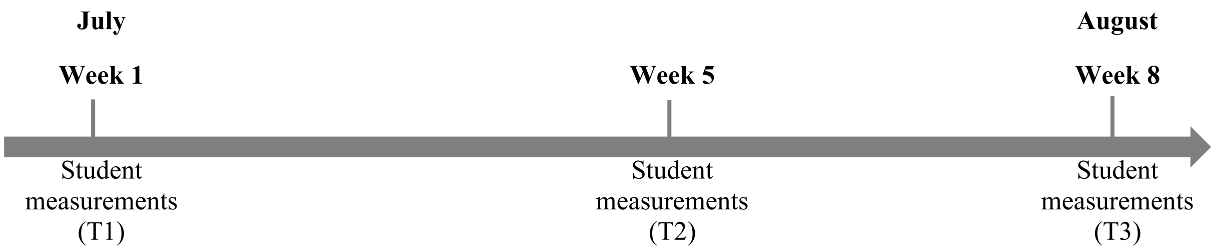

Figure 1 Timeline and Three Data Collection Points

Data Collection Tool

The study assessed students' utilization of learning strategies using the Motivation and Learning Strategies Scale, initially developed by Pintrich and Smith (1993) and later adapted to Turkish by Karadeniz et al. (2008). This scale comprises two subscales: Motivation (24 items) and Learning Strategies (45 items). Pintrich and Smith (1993) asserted that the scale has a modular structure allowing implementers to use the subscales according to their specific purposes. In this study, the Learning Strategies subscale and the associated Cognitive Self-Regulation (Metacognition) scale (10 items) were employed. Karadeniz et al. (2008) reported that the scale, scored on a Likert scale from 1 (Absolutely wrong for me) to 5 (Absolutely right for me), encompasses 9 factors based on the findings of the confirmatory factor analysis (X^2 = 3288.17; df = 948; GFI = .89; AGFI = .87; CFI = .89; NNFI = .88; SRMR = .04; RMSEA = .05) confirming the predefined factors. Additionally, a satisfactory Cronbach's alpha coefficient (.85) was obtained for the scale in a previous study (Deniz, 2023), while the current study yielded a Cronbach's alpha coefficient of .82.

Data Analysis

Before commencing the data analysis, the dataset underwent a thorough examination to identify and address any missing data. It was observed that there were 12, 9, and 15 missing values in the first, second, and third measurements, respectively. Following the guidance of Tabachnick and Fidell (2013), the missing values were imputed with the mean of the series. Subsequently, the equivalence of the groups in terms of variables was assessed using a t-test. The analysis of the measurements obtained at three-time points was conducted using a mixed design ANOVA, which allowed for the examination of the effects of both between-group variables (e.g., gender: female/male) and time-dependent variables (within-groups) (Patton, 2020). To ascertain the reliability of the scale, Cronbach's alpha coefficient was employed. The results were interpreted at the predetermined alpha significance level of .05. Notably, the Z values fell within the range of ±3, indicating the absence of extreme values. Furthermore, the skewness and kurtosis values, as presented in Table 1, were within the range of ±1.96. The Levene test results affirmed the equality of error variances. Additionally, the results of the test of sphericity indicated that variance differences between all related group combinations were assumed to be equal, as the produced results were at the $p>.05$ level.

Results

Descriptive Statistics

Means, standard deviations, and correlations between study variables are presented in Table 2.

Table 2 Descriptive Statistics of Study Variables

Variables	M	S. d	Skew.	Kurt.	1	2	3
MLS (T1)	2.30	.83	.60	.02	1		
MLS (T2)	3.09	.92	.08	.29	.34**	1	
MLS (T3)	4.22	.47	.66	.16	.23**	.41**	1

$^{*}p<.05$
$^{**}p<.01$

In accordance with the findings presented in Table 2, it is observed that the variables fall within the ±1.96 skewness-kurtosis value range. Furthermore, the pairwise correlations indicate significant relationships among the variables measured at three distinct time points, with none of these correlations surpassing the recommended 0.9 cut-off value as suggested by Hair et al. (2014).

Moreover, an examination of the study variable at time point T1 involved a comparison based on gender and school groups. The outcomes of the t-test analysis can be found in Table 3, while the ANOVA results are provided in Table 4.

Table 3 The Results of the T-Test Analysis Indicate the Equivalence of Gender with Respect to the Study Variables

Variables	Groups	Group statistics			Levene test		t-test		
		n	M	S. d.	F	p	t	df	p
MLS (T1)	Female	321	2.27	.81	1.12	.28	.63	575	.52
	Male	301	2.32	.85					

Based on the t-test analysis findings, there is no statistically significant disparity between males and females with regard to MLS measured at the T1 time point. As there is no discernible distinction between the groups, the outcomes derived can be extrapolated to the study cohort. ANOVA analysis was employed to ascertain if there are variations among the school groups in relation to the study variables.

Table 4 The ANOVA Results Indicate the Equivalence of School Groups in Terms of Study Variables

Variables	ANOVA					Post-hoc (Tukey HSD)				
	S. s.	df	M. s.	F	p	Schools	School order	M. dif.	Std. e.	p
MLS (T1)	3.87	3	1.29	1.85	.13	1	2	-.08	.09	.84
							3	-.13	.10	.50
							4	-.22	.09	.10
						2	3	-.05	.09	.93
							4	-.14	.09	.45
						3	4	-.08	.09	.82

As per the ANOVA results outlined in Table 4, it is evident that the data derived from MLS at time point T1 does not exhibit a significant variance across the four schools. This conclusion is further supported by the follow-up Tukey HSD analysis. Hence, it can be posited that all participants in the initial time period hold similar perceptions regarding MLS.

Mixed Design ANOVA Results

In conducting mixed design ANOVA analysis, it is imperative to ensure that the assumption of sphericity is satisfied. According to this assumption, the differences in variance scores across any two conditions must be equivalent (Pallant, 2020). To assess this assumption, Mauchly's Test of Sphericity, available in SPSS, was employed. The test result ($X^2_{(2)}$ = 44.80, p>.05) indicated that the assumption of sphericity (ε = .92) was upheld. Additionally, it is essential to address the assumption of homogeneity of variances.

In the analysis, Levene's test was conducted for each level of the repeated measures variable. The results indicated that the test was not significant at all three time levels (*p* = .30, p = .10, *p* = .20), suggesting that the assumption of homogeneity of variances was not violated.

The mixed design ANOVA yielded significant results pertaining to the variations in students' perceptions of metacognitive learning strategies across the time points T1, T2, and T3, as well as the changes in scores for two distinct groups (male/female) over time.

Table 5 Utilizing a Mixed Design ANOVA to Evaluate the Time x Gender Interaction and between Time Points

Source		Tip III S.s.	df	M. s.	F	p	η^2
Time	Sphericity Assumed	1057.03	2	528.51	907.27	.00	.61
	Lower-bound	1057.03	1.00	1057.03	907.27	.00	.61
Time * Gender	Sphericity Assumed	.97	2	.48	.83	.43	.00
	Lower-bound	.97	1.00	.97	.83	.36	.00
Error (Time)	Sphericity Assumed	665.25	1142	.58			
	Lower-bound	665.25	571.00	.16			

Based on the findings presented in Table 5, the interaction between time and gender does not yield statistically significant results, as indicated by a p-value greater than .05. This suggests that there is no significant difference in MLS scores between male and female students over time. Furthermore, the main effect of time is supported by a p-value of .00, signifying statistical significance. Therefore, it can be inferred that there is a substantial effect associated with time, indicating a change in MLS scores across different time periods. The effect size for the observed difference between time periods is .61, which, according to Cohen (1988), corresponds to a medium-level effect.

The statistical analysis in Table 6 indicates that the intergroup effect (*p* = .82) is not statistically significant. This suggests that there is no discernible difference between the MLS scores of female and male participants. Therefore, the gender of the student does not appear to significantly influence the perception of metacognitive learning strategies.

Table 6 Mixed Design ANOVA Results Reflecting the Main Effect of Variables between Groups

Source	Tip III S. s.	df	M. s.	F	p	η2
Intercept	5787.22	1	5787.22	28387.39	.00	.98
Gender						
Error	.01	1	.01	.05	.82	.00
	116.40	571	.20			

The statistical analysis in Table 6 indicates that the intergroup effect (*p* = .82) is not statistically significant. This suggests that there is no discernible difference between the MLS scores of female and male participants. Therefore, the gender of the student does not appear to significantly influence the perception of metacognitive learning strategies.

Pairwise comparisons between time periods reflecting within-group effects are presented in the table below and in Figure 2, along with the Bonferroni correction.

Table 7 Pairwise Comparison Between Time Periods

(I) Time	(J) Time	Mean difference (I-J)	Std. e.	p
1	2	$-.79^*$	.05	.00
	3	-1.92^*	.04	.00
2	1	$.79^*$	.05	.00
	3	-1.13^*	.04	.00
3	1	1.92^*	.04	.00
	2	1.13^*	.04	.00

To make the information in Table 7 more visible, information including post-hoc comparisons between all time points from T1 to T3 can be seen in Figure 2.

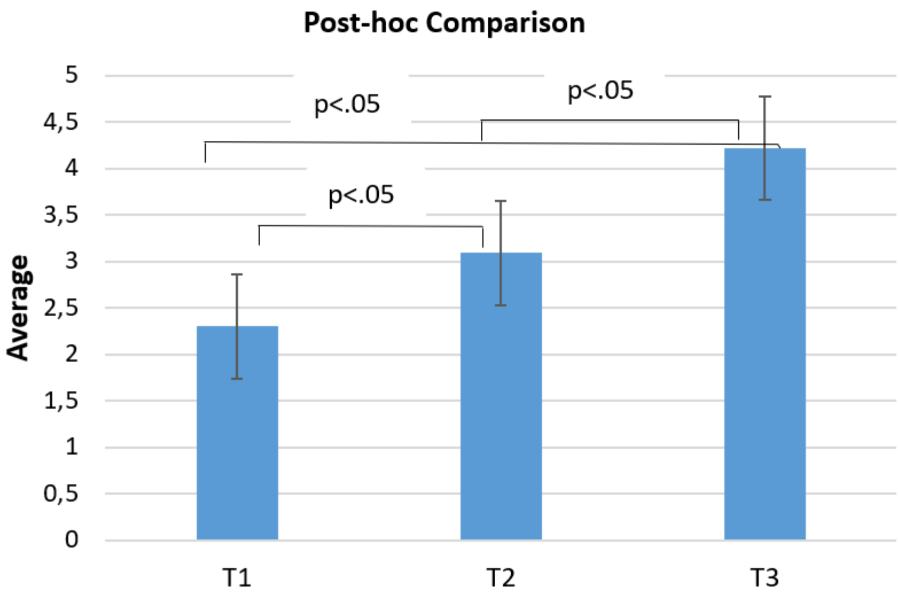

Figure 2 Post-Hoc Comparisons between Time Points

The findings in Table 7 and Figure 2, which stem from the post-hoc analysis, indicate a notable disparity at the $p = .00$ significance level across time periods 1-2, 1-3, and 2-3. Additionally, Figure 3 visually represents the association between time periods and the gender x time interaction.

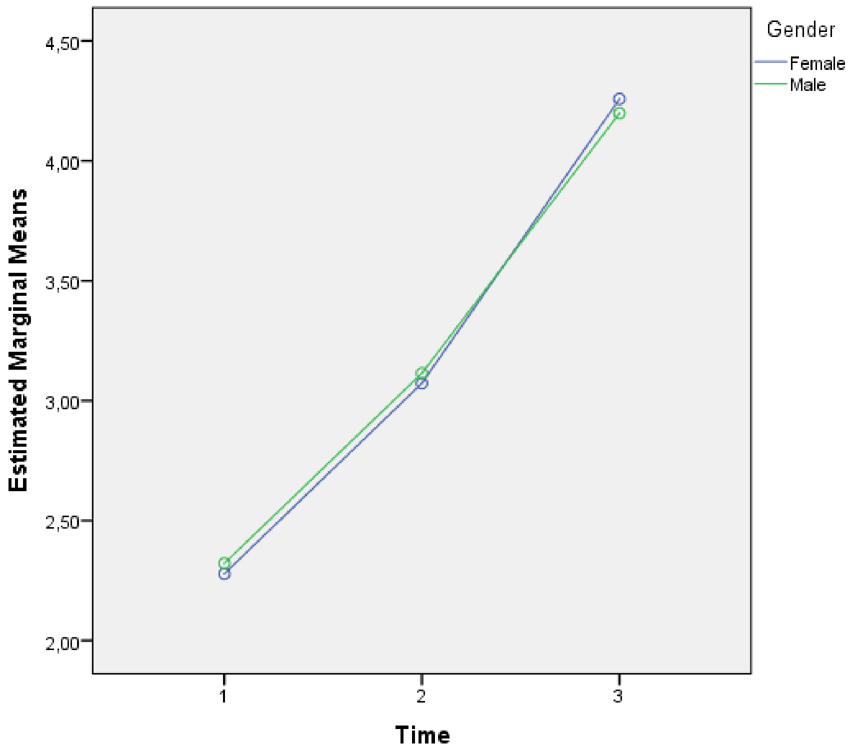

Figure 3 MLS Scores of Students in Time Periods

The data depicted in the graph concerning the time periods and gender x time interaction indicates that the disparity between time periods 1-3 is more pronounced than the variance between time periods 1-2 and 2-3. Furthermore, the gender x time interaction demonstrates a parallel trend, signifying the absence of a significant effect, aligning with the outcomes delineated in Table 6.

The present study employed a mixed design ANOVA to examine the impact of students' perceptions of metacognitive learning strategies (MLS) with respect to time, gender, and their interaction. The interaction of time and gender yielded a non-significant effect, $F(2, 1142) = .83$, $p = .43$, $\eta 2 = .00$, indicating no substantial difference in MLS scores based on gender. However, the main effect of time was found to be significant, $F(2, 1142) = 907.27$, $p = .00$, $\eta 2 = .61$, suggesting notable changes in students' MLS scores across different time periods.

Discussion

The concept of metacognition has emerged as a focal point in the realm of science education owing to its significant influence on cognitive processes and learning outcomes. In the domain of science education research, metacognition is frequently incorporated into studies that address the fundamental objectives of science education, rather than being studied in isolation. This indicates a growing emphasis on the development of metacognition within science education. This study sought to investigate the longitudinal utilization of metacognitive learning strategies among middle school students enrolled in a science course as part of the summer STC program. Specifically, the study aimed to ascertain whether there were disparities in the employment of metacognitive learning strategies between male and female students. The findings revealed noteworthy variations in students' employment of metacognitive learning strategies over time, indicating a consistent increase in the use of such strategies from the initial time point (T1) to the final time point (T3). This suggests that students increasingly engage in deep learning processes, such as directing, controlling, and regulating cognition and learning, which are indicative of metacognitive learning strategies, within the context of science courses offered as part of the STC program.

The existing literature on metacognitive awareness in middle school students has often focused on the impact of various variables unrelated to the current study, such as grade level, note-taking habits, experimental work, and their application in daily life (Bağçeci et al., 2011; Oğuz & Kutlu Kalender, 2018; Öztürk & Serin, 2020). Limited research has investigated metacognitive learning processes and strategies within learning environments based on course selection and voluntary participation, which is the primary focus of this study. Notably, Aydın and Kılıç-Mocan (2022) conducted a study on the impact of science education on the metacognitive awareness levels of middle school students, demonstrating that voluntary participation in a science project significantly enhanced their metacognitive awareness. Similarly, Mudd (2010) revealed in his study, "Student Choice as a Motivational Strategy to Increase the Success of Middle School Students," that students exhibited higher motivation levels when given the opportunity to make choices. Furthermore, Birdsell et al. (2009) presented four options to middle school students -group selection, curriculum selection, assignment selection, and assessment selection- finding that providing choices led to increased self-motivation. In the study conducted by Frye (2010), it was revealed that the summer school course program for academic courses had significant effects on students' perceptions of motivation, effort levels, and learning responsibility behaviors, which are closely related to metacognition. Thuneberg et al. (2022) demonstrated the positive effects of out-of-school learning on MLS, abstract thinking, and complex reasoning, reflecting learner autonomy. Finally, in a study conducted in a computer-based learning environment (Bannert et al., 2015), it was concluded that students used the MLS autonomously without any instructional intervention. Consistent with these findings, the present study suggests that choice-based activities or learning tasks can enhance students' motivation and active participation in the course.

Researchers in various disciplines (e.g., English) who focus on the effects of metacognitive knowledge and strategies on learning environments suggest that they facilitate the development of student autonomy, are associated with perceptions of competence, and show positive correlations with task performance (Teng, 2020; Xiao & Zhao, 2024). Considering the importance of metacognitive knowledge and strategies for learning environments, it follows that students should be encouraged to use these strategies. STCs, which is effective in reinforcing out-of-school learning, are a good alternative to fill this gap. Therefore, it is important for teachers to direct students to STCs and for educational administrators to support the process with functional mechanisms.

The ongoing debate surrounding metacognition centers on its domain specificity and generality. Various factors contribute to the complexity of this debate, including the age of the students, the nature of the task, the specific metacognitive component under consideration, and the level and focus of analysis (Neuenhaus et al., 2011; Veenman, 2012). Nevertheless, research indicates that metacognition evolves within specific domains and tasks and can gradually be applied to multiple domains (Van der Stel & Veenman, 2013).

In contrast, several impediments hinder the integration of metacognition into standard scientific practices. Notably, educators' disciplinary expertise and ongoing professional growth can significantly influence the implementation of metacognitive strategies within educational settings. The contention put forth by knowledgeable educators regarding the dearth of suitable learning resources and time allocations (Zohar & Barzilai, 2013) suggests the presence of a disparity between theory and practice in this domain.

The issue at hand is influenced by both internal and external factors, particularly in the context of student-teacher dynamics. Within the middle school milieu, numerous students grapple with a lack of impetus to excel academically, which is evidenced through diminished test scores, non-participation in classroom activities, incomplete assignments, and a general disinterest in assuming the role of independent learners. Existing literature presents a multitude of rationales for the apparent dearth of motivation among students, attributing most of these reasons to intrinsic and extrinsic motivational factors (Liou et al., 2020; Ryan & Deci, 2020). Individuals lacking intrinsic motivation may manifest signs of boredom, a dearth of personal goals and interests, or a perception of being unchallenged in accordance with their skill level. Conversely, educators can also contribute to low motivation in students by demonstrating a lack of enthusiasm during lessons, imposing limited choices upon students, or failing to establish rapport with them (Ben-Eliyahu & Linnenbrink-Garcia, 2015; Böheim et al., 2021; Phillips & Lindsay, 2006). As per Birdsell et al. (2009), when students are afforded choices in learning tasks such as activities, lesson topics, assessments, and homework, they exhibit higher levels of initiative and engagement in the educational process. Consequently, the overall ambiance of the learning environment and student attitudes can be positively impacted.

The current study aimed to investigate whether there are differences in MLS scores based on gender. The findings revealed a non-significant effect of gender on students' perceptions of MLS, indicating that being a female or male student does not lead to significant differences in MLS scores. This result is consistent with previous research by Aydın and Kılıç-Mocan (2022) and Kandal and Baş (2021), suggesting that gender does not significantly impact MLS. However, contrasting results from Oğuz, Kutlu Kalender (2018), and Öztürk and Serin (2020) indicated that gender does create significant differences in the metacognition variable. The inconsistent results regarding metacognition may stem from variations in its conceptualization and the use of different measurement scales. Furthermore, the diversity in samples and contexts across studies may contribute to these inconsistencies.

Therefore, it is essential to establish refined definitions of metacognition to alleviate conceptual ambiguity and to explicitly state the adopted definition or conceptual framework in future studies.

Conclusion and Recommendations

The focus on metacognitive learning strategies as a motivational component within the context of science lessons is of significant importance. This study aims to demonstrate the potential contribution of choice-based science learning to the utilization of metacognitive learning strategies, highlighting the importance of empowering students to take responsibility for their own learning processes. By shifting the traditional role of the teacher as the primary responsible party, students are encouraged to assume accountability for their individual learning journeys. Furthermore, the encouragement of metacognition, which is integral to the development of students' scientific thinking and questioning skills (Ben-David & Zohar, 2009; Cooper & Sandi-Urena, 2009), through self-regulation, represents a key objective in science education. Given the significant impact of metacognition on learning outcomes, future studies could attempt to determine the benefits of metacognitive learning strategies across learning contexts. Notably, a comprehensive review of studies involving students across different age groups and diverse fields of study revealed that metacognitive skills accounted for 40% of the variance in learning outcomes (Veenman, 2011). As such, it is recommended that educators devote attention to the field of metacognition, recognizing it as a fertile area for potential academic advancement.

The current study points to the increasing importance of out-of-school learning in student outcomes, including MLS. However, despite the increasing importance of metacognition in science education, attempts to implement it in classroom settings are rare. Therefore, in order for metacognition and related learning strategies to find a place in routine science education, policy makers need to prepare processes that will facilitate this in curriculum and teacher education. Expanding the inclusiveness of courses to include students with high learning loss, declining interest in science, and socioeconomic disadvantages may increase homogeneity among students in terms of academic competencies. Students can be encouraged to participate in STCs by providing transportation, free and discounted lunch, and offering enrichment classes such as physical education and art that students are interested in. This can help prevent learning loss among students and increase their success in science classes.

The more time a student spends in school, the more knowledge they can acquire. Miller (2007) reports that summer vacations create many problems for students. These include learning loss, spending much of the first semester of the new school year reviewing the curriculum from the previous year, loss of motivation, and time away from school due to lack of supervision. Therefore, schools should attract students' attention with enriched programs that will enable continuous learning beyond the official work calendar. In this way, the negative effects of being away from the school context on academic success can be reduced. Considering the fact that students have much lower levels of academic skills than they should have in the transition from middle school to high school, it can be said that policy makers should add more accessible and functional applications such as STCs to their agendas.

This study was conducted in official state secondary schools where MoNE-financed STC science course summer term programs were implemented. Determining the MLS levels that are effective in developing students' science literacy skills and reducing learning losses is important in terms of revealing the effects of non-compulsory STC education contexts on student outcomes. Considering the prevalence of courses run through private educational institutions outside of official STC courses in Türkiye, it can be said that the components affecting MLS should be clarified, integrated into the curriculum components of science courses and other disciplines, and associated with educational outcomes.

The study at hand is concerned with the implications of science education research findings. An inquiry into whether the outcomes of this research can be extrapolated to other disciplines will be undertaken. The uncertainty surrounding this matter may be attributed to the intricate relationship between the generalizability and specificity of the field. Nonetheless, research on metacognition in the realm of science education, which delves into elucidating metacognitive learning strategies and fostering deep learning through guidance, control, and organization, is believed to possess cross-disciplinary applicability (Veenman, 2011; Veenman & Van der Stel, 2013). The findings of this study may shed light on previously overlooked performance indicators associated with metacognition. Furthermore, it is posited that science education activities encompassing metacognitive planning, evaluation, and control/regulation may be rendered more accessible, thereby presenting a promising avenue for further exploration. It is advisable to emphasize the significance of metacognitive knowledge/awareness. Metacognitive knowledge and metacognitive self-regulation are interconnected facets of metacognition. The development of metacognitive self-regulation is influenced by metacognitive knowledge, and vice versa (Efklides, 2008). Research has consistently demonstrated the substantial benefits of cultivating metacognitive knowledge/awareness in enhancing students' scientific thinking, questioning, and problem-solving abilities (Kaberman & Dori, 2009; Zohar & Ben David, 2008). Consequently, it is recommended that forthcoming studies on metacognition encompass diverse aspects of metacognition and assess the efficacy of experimental designs that encompass both metacognitive knowledge and metacognitive self-regulation.

This study was conducted by within the scope of a two-month course program due to the limitations of the research environment. The participants were 8th grade students. This short period, during which students make great efforts to prepare for the high school entrance exam and benefit from additional courses, is open to the effects of mediating variables affecting the cognitive processes of the students. For example, the steady increase in students' MLS levels may reflect the effects of mediating variables. Therefore, the results should be interpreted with caution. Repeated application in longer-term and extended contexts would be beneficial in enriching insights into metacognitive learning strategies and other components.

In conclusion, this study adds to the existing body of literature by shedding light on the impact of student choice as a motivational strategy in influencing metacognitive teaching strategies, which serve as a predictor of academic success.

Compliance with Ethical Standards

Disclosure of potential conflicts of interest

The author has no conflicts of interest to declare.

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CRediT author statement

Since the research was conducted by a single author, no specific roles were assigned.

Research involving Human Participants and/or Animals

This study was carried out taking ethical rules into account. The study was approvad by the Fırat University Social Sciences Ethics Committee (2022-9684).

Destekleme ve Yetiştirme Kursları Kapsamındaki Fen Dersine İlişkin Öğrencilerin Üstbilişsel Strateji Eğilimlerinin İncelenmesi

Özet:

Yaygın eğitim kapsamındaki destekleme ve yetiştirme kurslarında (DYK) öğrencilerin ders başarısının artırılması hedeflenmektedir; ancak, bu süreçte öğrencilerin motivasyonel bileşenlere ilişkin algılarının ne yönde değiştiği dikkate alınmamaktadır. Bu ihtiyaca yönelen bu araştırma, yaz dönemi DYK kapsamındaki öğrencilerin fen dersi bağlamındaki motivasyonel bir bileşen olan üstbiliş öğrenme stratejilerine (ÜÖS) ilişkin algılarının boylamsal eğilimlerine odaklanmıştır. İlişkisel tarama modelinde yürütülen bu araştırmaya, dört farklı ortaokuldan toplamda 622 öğrenci (%51.6 kadın; %48.4 erkek) katılmıştır. Ulaşılan sonuçlara göre, öğrencilerin ÜÖS kullanma eğilimleri, boylamsal olarak anlamlı düzeyde artmıştır. Buna ek olarak, kadın ve erkek öğrencileri yansıtan gruplar arası sonuç, iki grubun ÜÖS puanları arasında anlamlı bir farklılık oluşmadığını yansıtmaktadır. Öğrencilerin herhangi bir öğretimsel müdahale olmadan ÜÖS puanlarının artması, seçime dayalı DYK'nın öğrencilerin öğrenme görevlerine aktif katılımını artırdığı ve derse yönelik motivasyonel süreçleri teşvik ettiğini göstermektedir. Bu da öğrencilerin öğrenme sırasında ve sonunda bilişsel stratejileri aktif olarak kontrol ettikleri anlamına gelmektedir. Sonuçlar, öğrencilerin fen dersine yönelik yaygın ve informal öğrenme ortamlarından daha fazla yararlanmalarının gerektiğini göstermektedir. Kursların kapsayıcılığının, öğrenme kayıpları yüksek olan, fen dersine karşı ilgi düzeylerinde gerileme olan ve sosyoekonomik dezavantajlara sahip olan öğrenciler dahil edilerek genişletilmesi, öğrenciler arasında akademik yeterlikler açısından homojenliği artırabilir. Dolayısıyla, üstbiliş ve buna bağlı öğrenme stratejilerinin rutin fen eğitiminde yer edinebilmesi için, politika yapıcıların öğretim programlarında ve öğretmen eğitiminde bunu kolaylaştıracak süreçleri hazırlamaları gerekmektedir.

Anahtar kelimeler: Üstbiliş, okul dışı eğitim, fen eğitimi, fen öğretimi, ortaokul öğrencileri.

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