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The relationship between mathematics-focused epistemological beliefs and metacognitive awareness of secondary school students

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ABSTRACT

This study investigates the relationship between secondary school students' mathematics-focused epistemological beliefs and their metacognitive awareness. Employing a correlational survey design, the sample comprises 494 students in Türkiye. Data were collected using the Mathematics-Focused Epistemological Belief Scale and the Metacognitive Awareness Scale for Children. The findings indicate that students' belief that learning depends on effort (BLDE) is at a high level, while the belief that learning depends on ability (BLDA) and the belief in a single truth (BST) are at moderate levels. Metacognitive awareness was also found to be high. A moderate, positive correlation was observed between BLDE and metacognitive awareness, whereas the correlation between BST and metacognitive awareness was negative and weak. No significant relationship was found between BLDA and metacognitive awareness. Regression analysis revealed that the BLDE dimension significantly predicted metacognitive awareness. Additionally, variables such as gender, grade level, parental education level, and average daily study time were analyzed in relation to the sub-dimensions. The results highlighted that increased effort belief was consistently associated with higher metacognitive awareness across subgroups, while belief in a single truth tended to relate negatively. These findings underscore the importance of fostering epistemological beliefs centered on effort to enhance students' metacognitive skills, which are crucial for effective mathematical learning and problem-solving.

Contribution /Originality: This study uniquely examines the predictive relationship between specific dimensions of mathematics-focused epistemological beliefs and metacognitive awareness in secondary school students, incorporating multiple demographic variables. Unlike prior research, it highlights the critical role of effort-based beliefs in shaping metacognitive development through a comprehensive, variable-sensitive approach.

1. INTRODUCTION

For centuries, mathematics has been developed and utilized to explain natural phenomena and identify patterns. Mathematics is broadly defined as the discipline that explores the properties of quantities through concepts such as arithmetic, algebra, and geometry. Mathematics is regarded as a fundamental means of understanding life, offering a structured approach to thinking through its numerical and operational frameworks [1].

In recent years, there have been various discussions about the teaching methods of mathematics. The fact that mathematics instruction is insufficient for real life, students' inability to demonstrate adequate problem-solving skills, and their focus on performing operations quickly and reaching the correct results instead of thinking about the

problem and strategies for the solution have resulted in a proliferation of investigations and research on this subject [2-4]. The primary objective of mathematics instruction is to equip individuals with the essential mathematical knowledge and abilities necessary for everyday life, to instruct them in problem-solving methodologies, and to cultivate a mindset conducive to addressing challenges within the problem-solving framework [5].

Today, mathematics is perceived not merely as a compilation of abstract concepts and skills to be acquired, as it formerly was, but rather as knowledge and skills grounded in modeling reality, developed through problem-solving and comprehension of the issues at hand. In accordance with this understanding, the aim of mathematics teaching is to create a mathematical predisposition in the individual and to provide students with the concepts and skills of abstract mathematics [6]. Concepts regarding the nature of mathematical knowledge and practice, as well as students' comprehension of mathematics, will influence their learning methodologies and the understanding and competencies they develop [7].

2. THEORETICAL BACKGROUND

Learners learn by structuring information in the context of their individual differences, not as it is presented to them Perkins [8]. Bloom [9] stated that schools have an impact on the individual differences among students and that these differences are critical for learning. Darling-Hammond [10] emphasizes that environment and life have an impact as much as heredity in determining individual differences. Bandura [11] stated that differences between individuals occur as a result of heredity, social environment, and learning, and that these three factors generally affect the cognitive, affective, and personal characteristics of the individual. Due to these effects, individuals behave in different ways, and their levels of success differ [12].

The beliefs and values held by learners, who are considered the most important pillars of the education system, have an impact on the formation of individual differences. Recently, it has been observed that educators have focused on people's beliefs and epistemological development. The most important reason for this is that theoretical studies support the effect of individual factors on success [13]. It is claimed that the strongest determinant of all the decisions people make throughout their lives, all the choices they make, and all the behaviors they exhibit are their beliefs [14]. Beliefs are internal assumptions or propositions that shape an individual's perception, interpretation, and behavior toward any event, occurrence, person, or object encountered in life [15]. While some researchers consider beliefs as a type of knowledge Alexander, et al. [16], others argue that knowledge is a type of belief Woolfolk-Hoy and Murphy [17]. Nespor [18] states that people encode information into their memories semantically and encode beliefs into memories based on the events they experience. The epistemological belief that constructive theory focuses on is one of these beliefs [14].

Individuals' epistemological beliefs regarding the nature of knowledge and learning are associated with their comprehension, metacognitive awareness, perseverance, and interpretation of information [19]. Recent investigations have examined students' epistemological beliefs regarding the nature of knowledge and learning, positing that these beliefs are integral to the mechanisms of metacognition [20, 21]. Moreover, data indicate that epistemological beliefs influence performance in academic activities, including mathematical problem-solving Schoenfeld [20], persistence when confronted with challenging tasks Dweck and Leggett [22], and reading comprehension [23].

In the learning process, being able to understand the information is as important as the knowledge itself because learning at school largely depends on understanding. It is known that metacognitive awareness, referred to as learning to learn, supports reading comprehension and thus increases success [24]. Metacognition, within the framework of learning processes, entails the deliberate utilization and regulation of cognitive functions [25]. Metacognition is described as the process of reflecting on one's own thought processes [26]. Metacognition can be defined as a higher-level structure that views the cognitive system from above and manages it and is also a part of

the cognitive system Jia, et al. [27]. Healy [28] defined the concept of metacognition as thinking about thinking and people stepping back and reviewing their own learning strategies and mental operations.

Metacognitive awareness is defined as "using a deep-thinking process to raise awareness regarding the knowledge of the individual, task, and strategy in a certain situation" [29]. According to Woolfolk-Hoy et al. [30], metacognitive awareness is important because students need metacognitive awareness to control and be aware of the use of different creative learning strategies. Brown [31] defined metacognitive awareness as people's awareness of the thinking processes they use in learning and problem-solving and their ability to regulate these processes. While Wellman [32] defines metacognitive awareness as the individual's knowledge of using cognitive states or processes such as memory, attention, knowledge, and assumptions, Blakey and Spence [33] defined metacognitive awareness as realizing what one knows or does not know and managing one's thoughts by organizing them. For success in mathematical contexts, individuals must use cognitive resources effectively and control what these resources are supported by.

Metacognitive awareness is a critical concept for individuals to comprehend the abstract realm of mathematics. The reason is that an individual with metacognitive awareness is someone who possesses high-level thinking abilities, can question, and makes an effort to obtain information independently Schraw and Dennison [24]. Schoenfeld [34] mentions three topics regarding metacognitive awareness in mathematics learning: beliefs/intuitions, our knowledge of our own thought processes, and self-regulation. In education, the individual is unique and important; this uniqueness reveals individual differences, and individual differences significantly affect learning. Metacognitive skills vary from person to person and are closely related to tendencies towards knowledge and learning. Therefore, there is a correlation between metacognitive awareness and epistemological belief [35-37]. Recent research in mathematics education shows that metacognitive awareness has gained more importance in recent years [38-40].

2.1. Research Aim and Research Questions

The beliefs of learners, who are considered the most important pillar of the education system, are also closely related to individual differences. Accordingly, epistemology is a philosophical discipline that examines the nature of knowing in general rather than the formation of cognitive processes, investigates problems related to knowledge, and examines the source and nature of knowledge, its accuracy, and limits [41]. Epistemological beliefs are generally expressed as a concept that includes beliefs and attitudes towards knowledge. As stated by Hofer and Pintrich [14], epistemological belief is generally expressed as 'beliefs in the nature of knowledge'. For this reason, studies based on epistemological beliefs have an important place in our age where the perception of information changes and production is achieved using information [13]. Mathematics-focused epistemological beliefs are, accordingly, beliefs about mathematics, the knowledge covered by mathematics, and the nature to which mathematics belongs. Mathematics-focused epistemological beliefs held by students are very effective in educational activities and mathematics achievement [42].

This study aims to investigate the relationship between secondary school students' mathematics-focused epistemological beliefs and their metacognitive awareness. The findings are expected to contribute to addressing gaps in educational practices and to inform future research in this field. The specific research questions guiding the study are as follows:

1. What are the levels of secondary school students' mathematics-focused epistemological beliefs and metacognitive awareness?
2. Is there a significant relationship between these beliefs and metacognitive awareness in relation to various demographic variables?
3. To what extent do mathematics-focused epistemological beliefs predict students' metacognitive awareness?

3. METHOD

Since the study aims to examine the relationship between secondary school students' mathematics-focused epistemological beliefs and metacognitive awareness in terms of different variables, it is deemed appropriate to use a correlational design. Correlational studies investigate the link between two or more variables without manipulating them in any manner [43].

3.1. Sample

While the general population of this research consists of secondary school students studying in Türkiye during the 2021-2022 academic year, the study population consists of secondary school students studying in Afyonkarahisar in the same academic year. The sample of the research consists of 494 secondary school students determined by the random sampling method from the study population. It is known that the units based on random sampling have an equal probability of being selected for the sample. Whether the sampling unit is a cluster or an element, the fact that all units in the framework of the universe to be created have an equal probability of being selected for the sample will lead to a stronger estimation of the universe values [44].

3.2. Instrument and Procedures

The 'Mathematics-Focused Epistemological Belief Scale' (MfEBS) developed by İlhan and Çetin [45] was used to determine the mathematics-focused epistemological beliefs of secondary school students. The scale consists of 27 items and three sub-dimensions. These dimensions are named 'Belief that Learning Depends on Effort' (BLDE), 'Belief that Learning Depends on Ability' (BLDA), and 'Belief that there is a Single Truth' (BST). The Cronbach's alpha reliability coefficient obtained by applying the MfEBS was calculated as $\alpha = .776$ for the BLDE dimension, $\alpha = .873$ for the BLDA dimension, and $\alpha = .486$ for the BST dimension.

In order to determine the metacognitive awareness of secondary school students, the 'Metacognitive Awareness Scale for Children' developed by Sperling et al. [46] and adapted into Turkish by Karakelle and Saraç [47] was used. The scale has 18 items and is one-dimensional. The Cronbach's alpha coefficient obtained by applying the Metacognitive Awareness Scale was calculated as $\alpha = .805$. As stated by Nunnally and Bernstein [48], whether a scale is reliable or not, a Cronbach's alpha value of .70 and above is considered sufficient. As can be seen, the data obtained from the analysis results show that the scales used for the study are appropriate and reliable.

3.3. Data Analysis

The data collected in the study were analyzed using statistical software. Initially, the suitability of the data for parametric tests was assessed. The normality of the total scores and mean values was examined through skewness and kurtosis coefficients, which were found to fall within the acceptable range of -2.0 to +2.0. According to George and Mallery [49], this range indicates a normal distribution. Based on these results, the use of parametric tests was deemed appropriate for further analysis.

Descriptive statistics values were used while analyzing the "what is the level of mathematics-focused epistemological beliefs and metacognitive awareness of secondary school students?" subproblem. Pearson Product Moment Correlation was used to analyze whether there was a relationship between the scales. While examining the relationship between mathematics-focused epistemological beliefs and metacognitive awareness, the process was carried out on the total scores obtained from the subdimensions of the epistemological belief scale.

Regression analysis was conducted to determine whether the level of metacognitive awareness predicted mathematics-focused epistemological beliefs. Before the analysis, it was checked whether the prerequisites for regression analysis were met, and Beta (β) coefficients and t-test results were taken into account in the interpretation. Partial correlation analysis was performed to examine the relationship in terms of variables. In order to make the

correlation coefficients comparable to each other, the correlation values were converted into standardized values (z values), and this transformation was applied using Fisher's formula stated below [50].

$$Z_r=\frac{1}{2}\log_e(\frac{1+r}{1-r})$$

The difference between the standardized correlation coefficients was calculated using the formula stated below [50].

$$Z_{dif.}=\frac{Z_{r1}-Z_{r2}}{\sqrt{\frac{1}{N1-3}+\frac{1}{N2-3}}}$$

If the result obtained using this formula corresponds to a value of 1.96 and above, it is considered that there is a significant difference between the standardized correlation coefficients. It is stated that there is no significant difference if it is smaller than this value [50]. A significance level of 0.05 was used in all analyses in the study.

4. RESULTS

In the study, the distribution of secondary school students' mathematics-focused epistemological beliefs and metacognitive awareness is presented in Table 1.

Table 1. Distribution of mathematics-focused epistemological beliefs and metacognitive awareness.

Dimension	N	Number of items	X	SD
BLDE	494	10	3.98	0.57
BLDA	494	10	2.89	0.89
BST	494	7	2.96	0.57
Metacognitive awareness	494	18	3.75	0.57

It was found that the epistemological beliefs of the students were at a 'high' level in the BLDE dimension, at a 'medium' level in the BLDA and BST dimensions. This indicates that secondary school students' mathematics-focused epistemological beliefs were developed in the BLDE dimension but were not developed in other dimensions. Metacognitive awareness of secondary school students was found to be at a high level. Hence, the level of metacognitive awareness of secondary school students was high.

The results of the Pearson Product-Moment Correlation analysis, which was conducted to examine the relationship between mathematics-focused epistemological beliefs and metacognitive awareness levels of secondary school students, are shown in Table 2.

Table 2. The relationship between mathematics-focused epistemological beliefs and metacognitive awareness.

Mathematics-focused epistemological belief			
	BLDE	BLDA	BST
Metacognitive awareness	r=0.372**; p=0.00; n=494	r=-0.028; p=0.54; n=494	r=-0.092*; p=0.04; n=494

Note: **p<.01; *p<.05.

As a result of the analysis, it is observed that there was a positive and moderate relationship between the metacognitive awareness level of secondary school students and the BLDE. There was no significant relationship between metacognitive awareness and the BLDA. It is noted that there was a negative and low relationship between metacognitive awareness and the BST.

The results obtained from the partial correlation analysis conducted to determine whether there is a significant relationship between the sub-dimensions of secondary school students' mathematics-focused epistemological beliefs and their metacognitive awareness in terms of variables are presented below. The results regarding the gender variable are provided in Table 3.

Table 3. The relationship between mathematics-focused epistemological beliefs and metacognitive awareness in terms of gender.

Gender	Mathematics-focused epistemological belief	Metacognitive awareness
Female (n=261)	BLDE	r=0.347**; p=0.00
	BLDA	r=-0.073; p=0.23
	BST	r=-0.127*; p=0.04
Male (n=233)	BLDE	r=0.396**; p=0.00
	BLDA	r=0.049; p=0.45
	BST	r=-0.032; p=0.62

Note: **p<.01; *p<.05.

As a result of the analysis, it was found that there was a positive and moderate relationship between the BLDE and metacognitive awareness for both female and male students. It was determined that the relationship between the BLDA and metacognitive awareness was not significant for both female and male students. While it was determined that there was a negative and low relationship between the BST and metacognitive awareness for female students, the relationship was not significant for male students.

When the standardized values of the correlation coefficients are compared, the relationship between all dimensions of mathematics-focused epistemological belief and metacognitive awareness of male and female students does not show a significant difference. The results regarding the grade level variable are given in Table 4.

Table 4. The relationship between mathematics-focused epistemological beliefs and metacognitive awareness in terms of grade level.

Grade level	Mathematics-focused epistemological belief	Metacognitive awareness
5th Grade (n=49)	BLDE	r=0.293*; p=0.04
	BLDA	r=-0.120; p= 0.41
	BST	r=-0.292*; p=0.04
6th Grade (n=114)	BLDE	r=0.492**; p=0.00
	BLDA	r=0.015; p=0.87
	BST	r=-0.063; p= 0.50
7th Grade (n=205)	BLDE	r=0.319**; p=0.00
	BLDA	r=0.014; p=0.83
	BST	r=-0.042; p=0.54
8th Grade (n=126)	BLDE	r=0.378**; p=0.00
	BLDA	r=-0.056; p=0.53
	BST	r=-0.130; p=0.14

Note: **p<.01; *p<.05.

As a result of the analysis, while there was a positive and low correlation between the BLDE and metacognitive awareness for the 5th-grade students, a positive and moderate relationship was observed for the 6th, 7th, and 8th-grade students.

It was observed that the relationship between the BLDA and metacognitive awareness was not significant for all grade levels. It was noted that there was a negative and low relationship between the BST and metacognitive awareness for the 5th grade, but the relationship was not significant for the 6th, 7th, and 8th grade levels.

As a result of the partial correlation analysis performed according to grade level, standardized correlation values were compared, and it was determined that there was a significant difference between the relationships of the 5th grade and 8th grade students (z=2.99>1.96) with regard to the BLDA dimension in favor of the 8th grade students. The results regarding the mother's education level variable are given in Table 5.

Table 5. The relationship between mathematics-focused epistemological beliefs and metacognitive awareness in terms of mothers' education level.

Mother's education level	Mathematics-focused epistemological belief	Metacognitive awareness
Primary school (n=145)	BLDE	r=0.316**; p=0.00
	BLDA	r=-0.106; p=0.20
	BST	r=-0.110; p=0.18
Secondary school (n=224)	BLDE	r=0.437**; p=0.00
	BLDA	r=0.100; p=0.13
	BST	r=-0.037; p=0.58
High school (n=94)	BLDE	r= 0.312; p= 0.00
	BLDA	r= -0.114; p= 0.27
	BST	r= -0.139; p= 0.18
Undergraduate (n=31)	BLDE	r= 0.398*; p= 0.02
	BLDA	r= -0.039; p= 0.61
	BST	r= -0.059; p= 0.75

Note: **p<.01; *p<.05.

As a result of the analysis, it was observed that there was a positive and moderate relationship between the BLDE and metacognitive awareness for both levels. It was noted that the relationship was not significant in the dimensions of BLDA and BST. When the standardized correlation values were compared as a result of the partial correlation analysis, the relationship between the dimensions of mathematics-focused epistemological belief and metacognitive awareness did not show a significant difference. The results regarding the father's education level variable are given in Table 6.

Table 6. The relationship between mathematics-focused epistemological beliefs and metacognitive awareness in terms of the father's education level.

Father's education level	Mathematics-focused epistemological belief	Metacognitive awareness
Primary school (n=97)	BLDE	r=0.390**; p=0.00
	BLDA	r=-0.173; p=0.09
	BST	r=-0.114; p=0.26
Secondary school (n=153)	BLDE	r=0.405**; p=0.00
	BLDA	r=0.111; p=0.17
	BST	r=-0.108; p=0.18
High school (n=181)	BLDE	r=0.351**; p=0.00
	BLDA	r=-0.020; p=0.78
	BST	r=-0.049; p=0.51
Undergraduate (n=63)	BLDE	r=0.320*; p=0.01
	BLDA	r=-0.172; p=0.17
	BST	r=-0.138; p=0.28

Note: **p<.01; *p<.05.

The analysis revealed a positive and moderate correlation between the BLDE dimension and metacognitive awareness across all levels of father's education. No significant relationships were found for the BLDA and BST dimensions. However, standardized correlation coefficients indicated a significant difference in the BLDA dimension between students whose fathers had a primary school education and those with a secondary school education ($z = 2.25 > 1.96$), favoring the latter group. Findings related to the variable of daily average study time are presented in Table 7.

Table 7. The relationship between mathematics-focused epistemological beliefs and metacognitive awareness in terms of daily average study time.

Daily average study time	Mathematics-focused epistemological belief	Metacognitive awareness
None (n=15)	BLDE	r=-0.041; p=0.00
	BLDA	r=-0.364; p=0.18
	BST	r=-0.513; p=0.05
0-1 hour (n=108)	BLDE	r=0.266**; p=0.00
	BLDA	r=-0.164; p=0.09
	BST	r=-0.092; p=0.34
1-2 hours (n=194)	BLDE	r=0.368**; p=0.00
	BLDA	r=0.118; p=0.10
	BST	r=-0.038; p=0.60
2-3 hours (n=108)	BLDE	r=0.491**; p=0.00
	BLDA	r=0.049; p=0.61
	BST	r=-0.093; p=0.33
3 hours and above (n=69)	BLDE	r=0.341**; p=0.00
	BLDA	r=0.002; p=0.98
	BST	r=-0.149; p=0.22

Note: **p<.01.

As a result of the analysis, while the relationship between the BLDE and metacognitive awareness was not significant for none, it was positive and low for 0-1 hour, positive and moderate for 1-2 hours, positive and high for 2-3 hours, and positive and moderate for 3 hours and above. While it was observed that there was a very close to negative and high-level significant relationship between the BST and metacognitive awareness regarding the level of 'none', it was observed that the relationship was not significant at other levels. Similarly, it was concluded that the relationship was not significant in BLDA.

As a result of the partial correlation analysis conducted according to the average daily study time, the standardized correlation values were compared. In the BLDA dimension, there were significant differences between 'none' and 3 hours and above in favor of 3 hours and above, between 0-1 hour and 1-2 hours in favor of 1-2 hours, and between 0-1 hour and 3 hours and above in favor of 3 hours and above.

The results of the simple linear regression analysis performed to examine another research question are shown in Table 8.

Table 8. A simple linear regression analysis regarding the predictive level of BLDE on metacognitive awareness.

Variable	B	Standard error	β	t	p	Binary r	Partial r
(Constant)	41.003	3.02		13.577	0.00*	-	-
BLDE	0.667	0.075		8.886	0.00*		
Metacognitive awareness	0.207	0.023	0.372			0.138	0.372
$R=0.372$; $R^2=0.138$; $F_{(1,492)}=78.960$; p=0.00							

Note: *p<.05.

According to Table 8, the BLDE dimension of belief is a significant predictor of metacognitive awareness ($p < 0.05$). The BLDE dimension of mathematics-focused epistemological belief predicts 14% of metacognitive awareness. Therefore, the BLDE dimension of secondary school students' mathematics-focused epistemological belief positively predicts their level of metacognitive awareness at a moderate level.

5. RESULTS AND DISCUSSION

In the study, it was first determined that the BLDE dimension was at a high level. This situation shows that secondary school students have developed mature epistemological beliefs. Accordingly, they believe that students should make an effort to learn mathematics, that effort should be taken into account even if they have the ability, that the difference in success levels between students is due to effort, and that students believe that effort is necessary to achieve success in mathematics. When the literature was examined, similar studies were found supporting the result

obtained [51-53]. In their studies, Bozpolat and Durdu [54] and Su [55] stated that the students' BLDE levels were at the agree level. In the studies of Bulut and Yılmaz [56]; Sadıç [57]; Eren [58], and Durdu [59], students have developed mature epistemological beliefs. According to Yılmaz [60], students believe that success largely depends on effort and that talent also contributes to success. Accordingly, it can be said that students have a strong belief that mathematics is a difficult subject to understand, that it is necessary to study regularly in order to understand and gain knowledge, and that they must make an effort to be successful.

It was observed that the BLDA dimension of the scale was at a 'medium' level. This situation shows that secondary school students in the study have underdeveloped/immature epistemological beliefs in this dimension. According to this result, it can be stated that students believe that ability in mathematics is a factor that makes a difference in learning and that not everyone who wants to learn can learn mathematics. Durdu [59]; Schommer and Dunnell [61] and Tumkaya [62] found in their studies that students have immature epistemological beliefs. This result partially supports the findings of the current study. Dursun Sürmeli [63] stated in his study that students had a medium level of belief in the BLDA dimension. Bozpolat and Durdu [54] and Su [55] reached a conclusion in line with our research, stating that the students' levels were at the undecided level.

In the study, the answers regarding the BST dimension were found to be at a 'moderate' level. This situation shows that secondary school students have immature epistemological beliefs in this dimension. This situation can be expressed as a part of the students advocating the idea that knowledge in mathematics is certain and unchangeable and that one cannot be successful without memorizing the formulas; in other words, knowledge can be obtained readily. However, information is not certain and has a complex structure [64]. Thinking that talent alone is sufficient and believing that there is only one truth creates a perspective that is contrary to knowledge, which develops and changes over time. For this reason, it should not be forgotten that information is revised according to the changing and renewed era.

Bozpolat and Durdu [54] and Su [55] reached a conclusion that supports our research by stating that students' BST levels were at the 'undecided' level, while Eren [58]; Durdu [59]; Yılmaz [60], and Sadıç [57] stated that they were at the undeveloped level. The reason why students have different levels in different dimensions of epistemological beliefs may be that beliefs are independent systems, as stated by Schommer [13]. In other words, an individual can be at different stages in terms of beliefs at the same time.

The study revealed that the metacognitive awareness levels of secondary school students were high. Mert [65]; Ağpak [66]; Özşahin [67]; Sarıkaya [68]; Turan [69]; Eke [70] and Yılmaz [71] stated in their studies that students possess a high degree of metacognitive awareness. These studies support the research results. In their studies, Jaleel [72] and Sirek [73] reached a medium level of metacognitive awareness and obtained results close to this research. The study revealed a positive and moderate correlation between the BLDE dimension and metacognitive awareness. It was observed that the relationship between the BLDA and metacognitive awareness was not significant. Simultaneously, a weakly significant negative correlation existed between the BST and metacognitive awareness. A linear relationship exists between BLDE and metacognitive awareness, and the student's belief that learning in mathematics teaching depends on effort contributes to the development of metacognitive awareness.

Yüzbaşıoğlu [74] found a moderate relationship between students' BLDE and metacognitive awareness. This finding appears to coincide with our study. Accordingly, he stated that the more positive the students' attitudes are, the more holistic their beliefs about learning become. Su [55] stated that there exists a weak, although positive, correlation between the students' impression of mathematics self-efficacy and the BLDE, a negative and moderate relationship between the BLDA, and a negative and moderate relationship between the BST. These results are similar to the research findings. It has been observed that the correlation between the BLDE and metacognitive awareness is higher than in other dimensions. Schoenfeld [20] stated in his study that students' beliefs about mathematics have a strong effect on their learning behavior and, indirectly, on their metacognitive awareness. As a result of their study, Schommer, et al. [21] stated that BST and metacognition were negatively related. The results obtained from the

study conducted by Dweck and Leggett [22] can be shown as evidence of the effect of students' beliefs about learning on their metacognitive awareness. These results are in line with our study; Koller [75] stated that there was a positive relationship between students' metacognition and the BLDE and a negative relationship with the BST. Buehl, et al. [76] stated that students believe that they should make more Ugras [77]. With secondary school students, a moderate positive association was found between students' metacognitive awareness and epistemological beliefs.

When the relationship in terms of gender was studied through partial correlation, it was found that there was a positive and moderate association in the BLDE dimension. While the relationship was not significant for the BLDA dimension, the relationship was negative and low for female students in the BST dimension. It was observed that there was no significant relationship for male students. The partial correlation revealed no significant difference in terms of the gender variable. In their studies, Sadıç [57] and Bulut and Yılmaz [56] concluded that students' epistemological beliefs do not differ according to gender. While Durdu [59] and Bozpolat and Durdu [54] found that there is no significant difference in the BST dimension of epistemological belief according to gender, Eke [70] and Spence, et al. [78] found that students' metacognitive awareness did not differ significantly in terms of the gender variable. When the relationship was examined in terms of grade level, a positive and low relationship was found in the BLDE for 5th graders. A moderately positive relationship was found in the 6th, 7th, and 8th grades. It was concluded that while the relationship between the BLDA and the BST for the 6th, 7th, and 8th grade levels was not significant, the relationship was negative and moderate for the 5th grade level in the BST dimension. As a result of the analysis, in terms of grade level, there was a significant difference between the 5th grades and the 8th grades only in the BLDE dimension in favor of the 8th grade. Bozpolat and Durdu [54] stated that while they did not find a significant difference in the BLDE and BLDA dimensions, the significant difference in terms of grade level in the BST dimension was in favor of the 9th grade. Durdu [59] also stated that there is a significant difference in terms of grade level in the BST dimension in favor of the 9th grade.

Variables related to the mother's and father's educational levels show a positive and moderate relationship found for primary, secondary, high school, and undergraduate levels in the BLDE dimension. However, there was no significant correlation between the dimensions of BLDA and BST. Due to the partial correlation, no significant difference was found in any dimension of epistemological belief for the mother's educational status. However, a significant difference was found in favor of secondary school for individuals studying at primary and secondary school levels in the BLDA dimension for the father's education level. This can be interpreted as the relationship between students' belief in their ability to learn mathematics and their metacognitive awareness being higher for students whose father's education level is secondary school compared to those whose father's education level is primary school. While Bulut and Yılmaz [56] found that the mother's education level did not make a significant difference for epistemological belief, Bozpolat and Durdu [54] stated that there is no significant difference in the BLDE and BLDA dimensions according to the variables of the mother's and father's education level, but that there is a significant difference in the BST dimension. When the relationship was examined in terms of average daily study time, it was seen that the relationship was not significant for the 'I do not study at all' level in the BLDE dimension. Additionally, there was a positive and low relationship for '0-1 hour', a moderate and positive relationship for '1-2 hours' and '3 hours and above', and a high positive relationship for '2-3 hours'. While the relationship was not significant in the BLDA dimension, a high level of negative correlation was found for the BST dimension at the level of 'none'. It was observed that the relationship was not significant for other study periods.

This result shows that the correlation between BLDE and metacognitive awareness increases as the daily study time increases. In other words, it seems that daily study time is an important variable for these two concepts. The correlation analysis revealed a substantial difference between 'I do not work at all' and '3 hours and above' in the BLDA dimension, in favor of '3 hours and above', between '0-1 hour' and '1-2 hours', in favor of '1-2 hours', and between '0-1 hour' and '3 hours and above' in favor of '3 hours and above'. This result can be interpreted as the relationship between the level of belief in ability in learning mathematics and their metacognitive awareness of

students who stated that they did not study at all, compared to students who stated that they gradually studied more. This shows that daily study time is effective in the relationship between ability and metacognition. According to Bozpolat and Durdu [54], there was a significant difference in daily study time in favor of '2 hours and above', and Durdu [59] stated that there was a significant difference.

In the last sub-problem, as a result of examining the level of prediction of BLDE on metacognitive awareness, it was concluded that this dimension is a significant predictor of metacognitive awareness. Accordingly, it can be stated that students' BLDE positively predicts metacognitive awareness at a moderate level. Chrysostomou and Philippou [79] stated that teachers' learning activities are an important predictor of their epistemological beliefs. While Mert [65] stated that students' metacognitive awareness predicts their success in mathematics, Yılmaz [71] stated that students' metacognitive awareness is significantly predicted by their attitudes towards the visual arts course. Schoenfeld [34] stated that students' academic success predicts their epistemological beliefs. Additionally, Koller [75] stated that epistemological beliefs predict students' success in mathematics, and reached results consistent with our study.

6. CONCLUSION

Within the framework of these results, in the overall study and within the variables examined, it was observed that secondary school students' metacognitive awareness and epistemological beliefs had a moderate positive relationship with the BLDE dimension, a low and negative relationship with the BST dimension, and that there was no relationship between them and the BLDA dimension. When the results are evaluated together, it is seen that the perception of the relationship between mathematics and effort is more established than other beliefs. At the same time, mathematics and the belief in a single truth are more established than the perception of ability. Mathematics success has an important place for all individuals in all walks of life, but the belief that making an effort in mathematics is important for students also affects the individual's metacognitive awareness. Similarly, the individual's belief that mathematical knowledge is certain and unchangeable negatively affects the individual's metacognitive awareness.

Also, depending on the results obtained, it can be said that the relationship between individuals' beliefs about ability and metacognitive awareness improves as the grade level increases. This finding can be interpreted as the fact that as the grade level increases, the student structures the information by systematizing it in his or her own thinking environment and becomes aware of his or her cognitive process by becoming aware of his or her own learning.

Metacognitive awareness is not only affected by age, maturation, or biological differences. Accordingly, metacognitive awareness may also occur as a result of experiencing differences, development, and learning [30]. Likewise, epistemological beliefs are not inherent and unchangeable psychological characteristics. They are phenomena that can evolve and progress over time and are closely related to mental development. They are also seen as very important structures in learning and teaching activities [80, 81]. For this reason, the importance of the education received by learners and teachers in terms of metacognitive awareness and epistemological beliefs is clearly seen.

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