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The relationship between personal epistemology and self-regulation among Turkish elementary school students

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ABSTRACT
The purpose of the study was to determine the level of the relationship among Turkish elementary school students' personal epistemologies, motivation, learning strategies, and achievements in science. A total of 322 fifth-grade students participated in the study. Results from the structural equation modeling showed that students' personal epistemologies influence both their motivation and metacognitive strategies in science learning. Viewing scientific knowledge as constructed by the learner contributes to the students having high motivations, high science achievement, and the ability to engage metacognitively in learning tasks.

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Metacognition; motivation; personal epistemology; science achievement; self-regulated learning

Personal epistemology and self-regulated learning are important elements of students' learning in general. Personal epistemology is defined as individuals' ideas about knowledge and knowing (Hofer, 2001). Self-regulated learning refers to a process in which students monitor their motivations, cognitions, and behaviors during an academic task (Winne, 1995). The purpose of this study is to determine the level of the relationship between elementary school students' personal epistemology and self-regulated learning and how that relationship predicts their achievement in science.

Personal epistemology can be viewed a base to describe the nature of science learning in the classrooms (National Research Council, 2007). Some studies on personal epistemology have documented how personal epistemology relates to students' learning strategies (Hammer, 1994; Kizilgunes, Tekkaya, & Sungur, 2009), practice of school science (Kittleson, 2011), conceptions of learning (Tsai, Ho, Liang, & Lin, 2011), and self-regulated learning (Bromme, Pieschl, & Stahl, 2010; Lin, Liang, & Tsai, 2012). Along with a recent emphasis on that students should develop some basic understanding of scientific knowledge (e.g., National Research Council, 2007); the field of the personal epistemology has drawn the attention of many researchers.

The developments of personal epistemology and self-regulated learning may depend on students' age (Buehl, 2008; Paris & Winograd, 1999; Zimmerman, 2000). At early ages, when first-time students are exposed to science instruction, students develop science-related personal epistemology that indicates students' ideas about scientific knowledge and knowing (Muis, Bendixen, & Haerle, 2006). However, most studies addressing personal epistemology and self-regulated learning have involved mainly students at high school or university levels (Yang & Tsai, 2012). Therefore, a need emerges to examine the interplay between personal epistemology and self-regulated learning with elementary science students who have just started developing their science-related personal epistemology and self-regulated learning.

Personal epistemology and achievement

Personal epistemology is defined as what individuals believe about what counts as knowledge and how knowledge is constructed and evaluated (Hofer, 2008; Hofer & Pintrich, 1997; Schommer, 1990). Hofer and Pintrich theorized personal epistemology as interrelated epistemic theories on the four dimensions of the beliefs. The first two dimensions that relate to the nature of knowledge are (a) the certainty of knowledge focuses on the strength of supporting evidence and (b) the development of knowledge refers to the connectedness of knowledge. The other two dimensions describe the process of knowing: (c) the justification of knowledge refers to how individuals proceed to evaluate knowledge claims, and (d) the source of knowledge is either that knowledge resides as an external source or is constructed by learners.

Studies addressing personal epistemology and academic achievement reported that students' personal epistemology may be associated with their academic achievement (Kizilgunes et al., 2009; Schommer, 1990). Earlier studies reported that students with more sophisticated personal epistemology on simplicity and certainty of knowledge had a higher grade point average (GPA; e.g., Kardash & Scholes, 1996). Schommer (1990), for example, investigated the influence of personal epistemology on students' achievement. Schommer reported that the students who had more sophisticated views on simplicity,

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certainty, fixed learning, and quick learning got a higher GPA score.

Relatively, few studies have examined personal epistemologies of elementary students (Yang & Tsai, 2012). Studies on personal epistemology with elementary students reported that elementary-aged students' personal epistemologies may develop at early ages (Conley, Pintrich, Wekiri, & Harrison, 2004; Driver, Leach, Millar, & Scott, 1996; Elder, 2002). Elder (2002) investigated fifth-grade students' ($N = 211$) science-related personal epistemology (e.g., the purpose of science, the source of scientific knowledge, the changeability of scientific knowledge). Elder reported that the elementary-aged students seemed to employ a mixture of naive and sophisticated personal epistemologies. More specifically, although students were inclined to define the purpose of science as completing projects rather than explaining a phenomena, elementary students appeared to acknowledge the changing nature of scientific knowledge. In another study, Conley et al. (2004) examined changes in personal epistemology of fifth-grade students. A total of 187 fifth-grade students were administrated a 26-item questionnaire measuring students' personal epistemology on source, certainty, development, and justification of knowledge. Conley et al. reported that after hands-on science activities longing for nine weeks, the students' personal epistemology changed over time and became more sophisticated in source and certainty of knowledge. However, the students did not show statistically significant improvement on development and justification of knowledge. In another study, Topçu and Yilmaz-Tuzun (2009) examined the relation among metacognition, personal epistemology and science achievement. A group of 941 Turkish elementary students participated in the study. Regression analysis revealed that students' personal epistemology on quick learning and fixed learning statically significantly predicted their GPAs ($\beta = -.10$ for both, $p < .001$). The authors concluded that for a better science achievement students' personal epistemologies should be developed in different dimensions.

Recently, some researchers argued that students' personal epistemology can account for an indirectly influence on students' practices and achievement (Muis, 2007; Schommer-Aikins, Duell, & Hutter, 2005). Schommer-Aikins et al. (2005) suggested that "personal epistemology's powerful influence is likely hidden because many of its effects are indirect rather than direct" (p. 291). In Topçu's and Yilmaz-Tuzun's (2009) study, for instance, metacognitive variable including knowledge of and regulation of cognition seemed to play more important role in science achievement than personal epistemology did. However, personal epistemology might have an indirect influence on science achievement through metacognition (Muis, 2007; Schommer-Aikins et al., 2005). Therefore, I believe it is important to associate personal epistemology with other more variables to predict students' science achievement and examine its indirect influence on science achievement.

Self-regulated learning and achievement

Self-regulated learning refers to the process that the learners monitor their thoughts, actions, and efforts to achieve their goals (Pintrich, 2002). Self-regulated learning consists of two components; motivational orientation and learning strategies (Pintrich, 2002). Motivational orientation refers to students' goals and value beliefs about a course and their beliefs about skills to achieve in the course (Zimmerman, 2008). Learning strategies include cognitive and metacognitive strategies that students use during a task (e.g., rehearsal, critical thinking; Pintrich, 2002).

Motivational dimensions (e.g., task value, goal orientation) of self-regulated learning should be an important part to lead students to use learning strategies effectively (Koksal, 2011). Goal orientation describes the reason why students engage in a learning task. Two types of goal orientation are (a) intrinsic goal orientation, referring to the reasons for internal rewards such as curiosity, and mastery; and (b) extrinsic goal orientation, referring to the reasons for external rewards such as grades, and performance. Intrinsically goal-oriented students, for example, are more highly engaged in learning, and use deeper cognitive strategies (Wigfield & Cambria, 2010). Task value refers to students' beliefs of how important and interesting the task is. For instance, students who view science as valuable to learn show more involvement in a learning task and make judgments about the outcomes of the learning task (Sungur, 2007). Control of learning belief concerns students' ideas that their effort will yield positive results in achievement. Self-efficacy is defined as the learner's judgment about his or her own ability to successfully complete the task (Bandura, 1997). Higher levels of self-efficacy were associated with higher levels of science achievement (Koksal, 2011). Test anxiety refers students' worries and anxiety that disrupt the performance. Test anxiety was found to be negatively influencing students' science achievement (Yumusak, Sungur, & Cakiroglu, 2007). Cavas (2011), for example, examined the influence of Turkish elementary students' motivational level on their science achievement. A total of 376 elementary students were administered a 33 item Likert-type questionnaire to map their motivation in science with responses ranging from 1 (*low motivation*) to 5 (*high motivation*). Analysis of variance analysis revealed that there was a statistically significant difference among the low-, moderate-, and high-motivated students, $F(2, 373) = 9.55$, $p < .001$. Students in the high motivated group achieved higher scores ($M = 4.12$, $SD = 1.14$) than the students in the low-motivated group ($M = 3.22$, $SD = 0.69$).

Likewise, cognitive and metacognitive dimensions of self-regulated learning are recognized as important in science learning (National Research Council, 2007). Metacognitively active students can decide how to use resources effectively, and make judgments about the outcomes (Sungur, 2007). Akyol, Sungur, and Tekkaya (2010) investigated the contributions of cognitive and metacognitive strategies students reported to their science achievement. A total of 1,517 seventh-grade students were administrated the 31-item learning strategies part of the Motivated Strategies for Learning Questionnaire (MSLQ). The reported Cronbach's alpha reliability were .65 for rehearsal, .76 for elaboration, .59 for organization, .72 for critical thinking, and .80 for metacognition for self-regulation. Regression analysis revealed that cognitive and metacognitive strategies explained 6.9% of the variance in students' science achievement. Strategies including elaboration ($\beta = .09$), organization ($\beta = .07$), and metacognitive self-regulation ($\beta = .11$) were found to statistically significantly predict students' science achievement.

Personal epistemology and self-regulated learning and achievement

Students' views on what knowledge counts and how to come to know may influence their use of information, and attention to particular features of information (Patrick & Pintrich, 2001). Hofer and Pintrich (1997) hypothesized that personal epistemology serves as goals that guide self-regulated learning. According to Muis (2007) and Bromme et al. (2010), personal epistemology is likely to shape learners' perceptions of tasks and therefore how the tasks are approached (Hofer & Sinatra, 2010). However, in science education there is still a need for further work to describe the connection between students´ personal epistemologies and self-regulated learning (Hofer & Sinatra, 2010).

Research on personal epistemology has demonstrated that students' beliefs about knowledge and knowing are related to their motivation for self-regulated learning. Muis and Franco (2009), for example, found that the belief on certainty of knowledge was related to extrinsic goal orientation ($\beta = .29$). Sophisticated beliefs on development of knowledge were associated with a more appreciating the value of learning task ($r = .17$), having a more intrinsic goal orientation ($r = .27$), feeling more confident about their capability to learn ($r = .20$; Paulsen & Feldman, 2005). Kizilgunes et al. (2009) examined the interplays among personal epistemology, motivation, learning approach and science achievement with 1,041 Turkish sixth-grade students. Kizilgunes et al. reported that students' ideas on development and source of knowledge were positively correlated to their self-efficacy and extrinsic goal orientation in leaning science. Kizilgunes et al. also examined the indirect effect of personal epistemology on students' achievement and found that only development of knowledge statistically significantly had indirect influence on science achievement ($\beta = .20$).

Additionally, students' personal epistemology has been associated with their cognitive and metacognitive strategies in learning science. According to Hofer (2004), students' ideas about knowledge and knowing serve as guides for cognition and metacognition for self-regulated learning. Personal epistemology may influence monitoring the learner's understanding of the complexity of problems, and the evaluation of evidence (Kuhn, 1991). For example, students who hold more sophisticated personal epistemology may evaluate the nature of knowledge in different contexts with reasonable flexibility (Stahl, Pieschl, & Bromme, 2006). Some researchers argue that the influence of personal epistemology on cognitive and metacognitive strategies is indirect through the moderation of motivational beliefs (e.g., Muis, 2007). While the learner uses any cognitive and metacognitive strategies for the self-regulated learning, for example, information generated by the learner serves as feedback to see if the established goals have been achieved (Muis, 2007). Paulsen and Feldman (2007) examined the relations between personal epistemology and cognitive and metacognitive strategies for self-regulated learning with 502 Norwegian undergraduate students and found that personal epistemology successfully explained 16.20% of the variance in students' cognitive and metacognitive strategies ($p < .05$). Naive beliefs on the development of knowledge were negatively correlated to elaboration ($\beta = -.18$) and positively correlated to rehearsal strategies ($\beta = .21$).

Considering the previous studies and literature, the purpose of this study is to examine the interplays among personal epistemology, self-regulated learning and science achievement by using structural equation modeling (SEM; see Figure 1). The first solid line in the model specifies the direct influence of personal epistemology on motivational dimensions of self-regulated learning. It was hypothesized that students' ideas about knowledge and knowing might directly predict their motivational beliefs including self-efficacy, task value, control of learning beliefs, and extrinsic and intrinsic goal orientations. The second solid line in the model is about the direct effect of motivational beliefs on cognitive and metacognitive strategies for self-regulated learning. It was hypothesized that students' motivational beliefs were directly related to students' use of cognitive and metacognitive strategies including rehearsal, organization, critical thinking, elaboration and metacognition for self-regulated learning. The first dashed line in the model specifies the indirect effect of personal epistemology on the cognitive and metacognitive strategies thought motivational beliefs for self-regulated learning. It was hypothesized that students' ideas about knowledge and knowing would be indirectly related to students' use of cognitive and metacognitive strategies through the moderation of motivational beliefs. The second dashed line represents the indirect influence of personal epistemology on students' achievement in science through the moderation of motivational beliefs and cognitive and metacognitive strategies. The third dashed line shows the indirect effect of motivational beliefs on students' achievement in science through the mediation of cognitive and metacognitive strategies. The last solid line in the model specifies the relations among cognitive and metacognitive strategies and science achievement.

Research on personal epistemology and self-regulated learning has contributed to our understanding of the nature of the relationship between personal epistemology and self-regulated learning in science learning. Researchers have suggested that research on personal epistemology and self-regulated learning should be extended in the following ways (a) should be focused on young learners (Moschner, Anschuetz, Wernke, & Wagener, 2008; Yang & Tsai, 2012), and (b) should pay attention to the indirect influence of personal epistemology on self-regulated learning (Schommer-Aikins et al, 2005). Additionally, little research has been conducted in Turkey in this respect (Kizilgunes et al., 2009). To address the gap in the literature, I sought the answers for the following research questions:

Research Question 1: What proportion of variance in the level of science achievement is explained by personal epistemology and self-regulated learning in Turkish elementary school students?

Research Question 2: To what extent do the dimensions of personal epistemology predict the motivational strategies that students use in science in Turkey?

Research Question 3: To what extent do the dimensions of personal epistemology indirectly express the cognitive

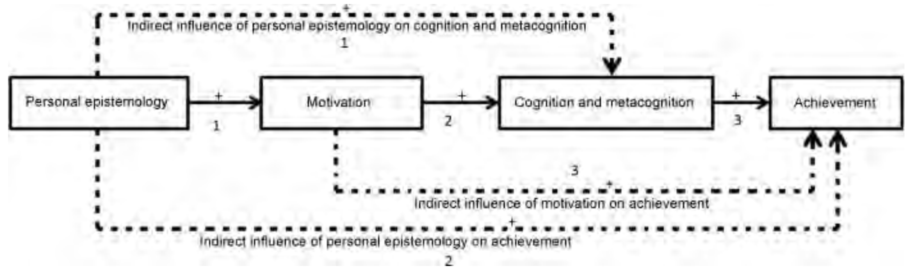

Figure 1. The hypothesized structural equation model of personal epistemology, self-regulated learning, and achievement.

and metacognitive strategies that students use in science in Turkey through motivational strategies?

Research Question 4: To what extent does the hypothesized SEM fit the data obtained from students in Turkey?

Methodology

Data collection and sample

In Turkey the youngest students taught by science teachers are enrolled in the fifth grade of the middle school level. The fifth-grade students in Turkey are the target population of the study. In this study, convenience sampling was used to reach the sample of the study. A metropolitan city located in the northwestern Turkey was chosen because of its convenience to the researcher. The Office of the Turkish Ministry of Education in the city granted the permission in four randomly selected public schools for data collection. Therefore, the fifth-grade students from these public elementary schools in the city were identified as the study participants. These schools were located in the city center. The students in these schools were moderate achievers and socioeconomically diverse. There were a total of 630 fifth-grade students in these four schools. Of these, 322 (152 girls) had their parental forms signed and volunteered to participate in the study. Data were collected in April 2013. All instruments were administrated to the students in regular class hour under the supervision of their science teacher. A total of two class hours were given to the students to complete the instruments. In the first class hour the students were given the first part of booklet that included demographic information (e.g., gender, age) and the Epistemic Beliefs Questionnaire (Conley et al., 2004) instrument, and then in the next class hour the second part of instrument booklet that included the MSLQ instrument was given the students. Negatively worded items in the questionnaire were bolded in the original questionnaire and the questionnaire booklet to get students' attention (see the Instruments section).

Instruments

The research methodology of the present study is a quantitative survey design to answer the research questions. Therefore, questionnaires as instruments are satisfactory enough to collect data. Questionnaires employed in this study are investigated based on the following criteria: (a) being adoptable to the domain of science, (b) capturing the facets of the two constructs, and (c) having been validated in Turkey. Two questionnaires determined to be helpful in collecting data from students are as followings. As the questionnaires were validated previously by other researchers, only confirmatory factor analysis (CFA) was conducted to verify its structures and dimensionalities.

Epistemic Beliefs Questionnaire

The Epistemic Beliefs Questionnaire (Conley et al., 2004) is a self-report instrument in a 5-point Likert-type scale comprises 26 items to measure the students' views about scientific knowledge. The EBQ was used and validated in the previous studies that included elementary students in Turkey (e.g., Ozkan & Tekkaya, 2011). The variables are certainty of knowledge (CER; 6 items), source of knowledge (SOU; 4 items [one item was deleted]), justification of knowledge (JUS; 9 items), and development of knowledge (DEV; 6 items). The source and certainty dimensions were stated from a naive perspective, thus items were reversed so that the higher score indicates more sophisticated beliefs. The results of the CFA analysis for the EBQ were the following: $\chi^2(290, N = 322) = 658.77$, $p < .001$; standardized root mean square residual (SRMR) = .07, root mean square error of approximation (RMSEA) = .078, comparative fit index (CFI) = .80. I used Hu and Bentler's (1999) model fit criteria with two fit indices to evaluate the model fit: (a) CFI values around .90 or the RMSEA values around .08 point out a moderate fit of the data to the model and (b) CFI values greater than .95 or RMSEA values less than .06 are indicative of a good fit. These results pointed out that the model was not fit with the expected level. Cabrera-Nguyen (2010) suggested using absolute cutoff values of .30 for factor loading. This step ended with deleting one items, item 19 (.25 of factor loading; source of knowledge). I reran CFA analysis for EBQ. The new CFA resulted in a moderate model fit, $\chi^2(243, N = 322) = 407.30$, $p < .001$; SRMR = .053, RMSEA = .057, CFI = .90.

Motivated strategies for learning questionnaire

The MSLQ as a self-report instrument in a 7-point Likert-type scale was developed by Pintrich, Smith, Garcia, and McKeachie (1991) to measure the students' self-regulated learning in any domain. The MSLQ has been validated and used by researchers at the elementary level in Turkey (e.g., Akyol et al., 2010). The questionnaire was adapted to science by adding *science* to the phrase *this course*. For example, item 2 was adopted as, "If I study in appropriate ways, then I will be able to learn the material in this science course." The variables are intrinsic goal orientation (INT; 4 items), extrinsic goal orientation (EXT; 4 items), task value (TAS; 6 items), control of learning beliefs

(CON; 4 items), self-efficacy (SEF; 8 items), test anxiety (ANX; 5 items), rehearsal (REH; 4 items), elaboration (ELA; 5 items [one item was deleted]), organization (ORG; 4 items), critical thinking (CRI; 5 items), and metacognitive self-regulation (MSR; 10 items [two items were deleted]). Because the MSLQ consists of two different subscales, motivational subscale (MS) and learning strategy subscale (LSS), a separated CFA analysis for each subscale was conducted (Pintrich et al., 1991). The results of CFA for the MSLQ-MS were in a good model fit (SRMR = .052, RMSEA = .062, CFI = .93). The CFA analysis for the MSLQ-LSS resulted with an SRMR of .067, RMSEA of .073, and CFI of .83. Due to low factor loading, three items including items 64 (.25 of factor loading; elaboration), 57, and item 61 (.21 and .28 of factor loading; metacognition for SRL) were deleted. I reran CFA analysis for MSLQ-LSS and obtained a moderate model fit, $\chi^2(423, N = 322) = 863.76$, $p < .001$; SRMR = .058, RMSEA = .059, CFI = .91. One item in the metacognitive self-regulation scale was negatively worded, so this item was reversed before a student's score was computed. I also examined Cronbach's alpha for reliability, ranging from .59 to .83, which indicates an acceptable value.

Science achievement

To determine students' achievement scores, some studies used achievement tests (e.g., Kizilgunes et al., 2009); others used students' final grade in the lesson (e.g., Muis & Franco, 2009). In this study, I decided to take students' final science grade in the semester that the study took place as their achievement score because an achievement test would take extra time of participants. Using students' final grade might be problematic because of a random assessment bias (Popham, 2012). However, as the achievement score data were obtained from eight science teachers in the four schools, the probability of this random assessment bias would be reduced and ignored. The students' final grades ranged from 1 (*failed*) to 5 (*excellent*).

Data analysis

To answer the research questions, SEM analysis was used on the Mplus 6 software (Version 6.12, Muthen & Muthen, Los Angeles, CA, 2011). One advantage of using SEM is that SEM provides for the direct estimation of all specific paths in the model (Kline, 2011). After that first model was run, the model fit as well as the modification indices were examined. Based on the modification indices, I place an inter-correlation between variable that the theoretical model allows.

Results

Descriptive statistics of students' personal epistemology (source, development, certainty, and justification), motivational orientations (intrinsic goal orientation, extrinsic goal orientation, task value, control of learning beliefs, self-efficacy, and test anxiety), and cognitive and metacognitive strategies (rehearsal, elaboration, critical thinking, organization, and metacognition for self-regulated learning) are shown in Table 1. The mean scores for personal epistemology and self-regulated learning were all above the midpoint of the 5-point (EBQ) and 7-point (MSLQ) Likert-type scales, except for source of knowledge. These mean scores indicated that participants demonstrated fairly naïve beliefs on source of knowledge (the mean, 2.95, was close to the midpoint, but below it), fairly sophisticated beliefs on development, certainty, and justification of knowledge (means were close to the midpoint, but above it), and high level of self-regulated learning (means were above midpoint; Conley et al., 2004).

To answer the research questions I used SEM via Mplus 6. Because low Cronbach's alpha values can influence the path coefficients and its direction, as suggested by Kline (2011), the sensitivity analysis was also conducted to examine the influence of measurement error. In sensitivity analysis, each subscale was used as an indicator of its latent variable (e.g., personal epistemology, motivation for self-regulated learning, cognitive strategies for self-regulated learning; Kizilgunes et al., 2009). I compared the fit indices of the original with that of the adjusted model. The adjusted model yielded better fit indices and explained more variance of science achievement than the original model did (See Table 2). There was no difference at the direction of any path between the adjusted model and the original model. Besides, because the adjusted model and the original model were basically identical, I interpreted only the original model.

Figure 2 presents the standardized study results based on the SEM analysis. The numbers on each path show the standardized path coefficient between each pair of the variables (β). In addition, the numbers located on the side of each variable is the proportion of the variance of each variable explained by the model (R^2). For the graphical simplicity, only statistically significant paths were demonstrated in Figure 2.

Overall, the fit statistics for the model show that the model fitted the data obtained from the elementary school students in the country well. CFI and the Tucker-Lewis index (TLI) were .91 and .90, respectively. These values supported the fit of the data to the model since the values of those indices were equal or higher than .90 (Kline, 2011). The chi-square statistic was significant (1147; $p < .01$). However, this result can be misleading because this statistic is affected by the sample size used in this study (Kline, 2011). The fit index of the RMSEA (.059) showed a good fit, which was lower than .06 acceptable values (Kline, 2011). The model is able to successfully explain the 27% variance of the observed variable GPA.

Table 1. Descriptive statistics of the variables.

	CER	JUS	SOU	DEV	INT	EXT	TAS	CON	SEL	ANX	REH	ELA	CRI	ORG	MSR	GPA
M	3.14	3.88	2.95	3.46	5.38	5.88	5.50	5.42	5.04	5.12	4.88	4.99	4.70	4.51	4.90	3.22
SD	0.89	0.81	0.80	0.82	1.50	1.31	1.39	1.49	1.37	1.09	1.61	1.44	1.48	1.67	1.19	1.03
Cronbach's α	.65	.81	.59	.74	.68	.70	.82	.62	.80	.71	.60	.80	.67	.65	.83	

Table 2. Fix indices of the original and adjusted models.

Model	CFI	TLI	SRMR	RMSEA	R^2
Original	.91	.90	.055	.059	.27
Adjusted	.95	.95	.042	.050	.35

Note. CLI = comparative fit index; TLI = Tucker-Lewis index; SRMR = standardized root mean square residual; RMSEA = root mean square error of approximation.

Examination of the path coefficients revealed that some dimensions of personal epistemology were statistically significantly associated with few dimensions of motivation for self-regulated learning: yet, others were not. All statistically significantly path coefficients were positive, indicating the more sophisticated beliefs students hold the higher motivation they reported for science except the links between CER and ANX, and ORG and GPA (See Table 3). Beliefs about the justification of knowledge had statistically significantly a positive effect on extrinsic goal orientation ($\beta = .15$), task value ($\beta = .28$), and self-efficacy ($\beta = .18$). The certainty of knowledge were statistically significantly correlated to only test anxiety ($\beta = .10$). Beliefs about the source of knowledge were statistically significantly correlated to intrinsic goal orientation ($\beta = .23$), extrinsic goal orientation ($\beta = .15$), control of learning belief ($\beta = .22$), and self-efficacy ($\beta = .17$). The development of knowledge were statistically significantly associated with intrinsic goal orientation ($\beta = .15$) and task value ($\beta = .11$).

Additionally, intrinsic goal orientation statistically significantly predicts students' use of elaboration ($\beta = .27$), critical thinking ($\beta = .18$), and metacognition for self-regulated learning strategies ($\beta = .28$). Extrinsic goal orientation was statistically significantly associated with rehearsal ($\beta = .28$), elaboration ($\beta = .24$), organization ($\beta = .18$), critical thinking ($\beta = .18$), and metacognition for self-regulated learning strategies ($\beta = .18$). Task value was statistically significantly correlated with rehearsal ($\beta = .17$), elaboration ($\beta = .11$), critical thinking ($\beta = .18$), and metacognition for self-regulated learning strategies ($\beta = .22$). Self-efficacy was statistically significantly correlated with all dimensions of cognitive strategies including rehearsal ($\beta = .23$), elaboration ($\beta = .25$), critical thinking ($\beta = .31$), organization ($\beta = .31$), and metacognition for self-regulated learning strategies ($\beta = .32$). On the other hand, control of leaning beliefs and test anxiety were not statistically significantly correlated to any dimension of cognitive and metacognitive strategies.

Science achievement was statistically significant correlated to all cognitive and metacognitive strategies except rehearsal strategies. Organization strategies were negatively correlated to the science achievement ($\beta = -.13$). The relationship between rehearsal strategies and science achievement were not statistically significant ($\beta = .02$). The strongest positive direct effect on science achievement was from metacognition for self-regulated learning ($\beta = .35$). Science achievement was associated positively with elaboration ($\beta = .20$) and critical thinking ($\beta = .19$).

Additionally, the total indirect influences of the variables on the model were examined. Examination of the total indirect effect of personal epistemology on self-regulated learning strategies revealed statistically significant effects of personal epistemology on the self-regulated learning strategies and science achievement. Beliefs about justification and source of knowledge explained statistically significant variance in all cognitive and metacognitive strategies and science achievement including rehearsal ($\beta = .13$ and $\beta = .08$), elaboration ($\beta = .12$ and $\beta = .12$), critical thinking ($\beta = .14$ and $\beta = .12$), organization ($\beta = .09$ and $\beta = .08$), metacognition ($\beta = .17$ and $\beta = .16$), and science achievement ($\beta = .10$ and $\beta = .09$), respectively. The total indirect effects of certainty of knowledge on any cognitive and metacognitive strategies and science achievement were not statistically significant. Beliefs about development of knowledge were indirectly associated with rehearsal ($\beta = .06$), elaboration ($\beta = .08$), critical thinking ($\beta = .09$), metacognition ($\beta = .12$), and science achievement ($\beta = .07$). The strongest total indirect effect from motivational factors on science achievement was from intrinsic goal orientation ($\beta = .18$). Science achievement was also indirectly associated with extrinsic goal orientation ($\beta = .12$), task value ($\beta = .13$), and self-efficacy ($\beta = .18$).

To sum up, sophisticated beliefs in justification of knowledge were related to higher levels of self-efficacy, task value, and extrinsic goal orientation. The beliefs about the certainty of knowledge was only associated with test anxiety. Results also indicated that beliefs about developmental nature of knowledge were related to intrinsic goal orientation and task value. Similarly, beliefs about source of knowledge were positively associated with intrinsic and extrinsic goal orientations, control of

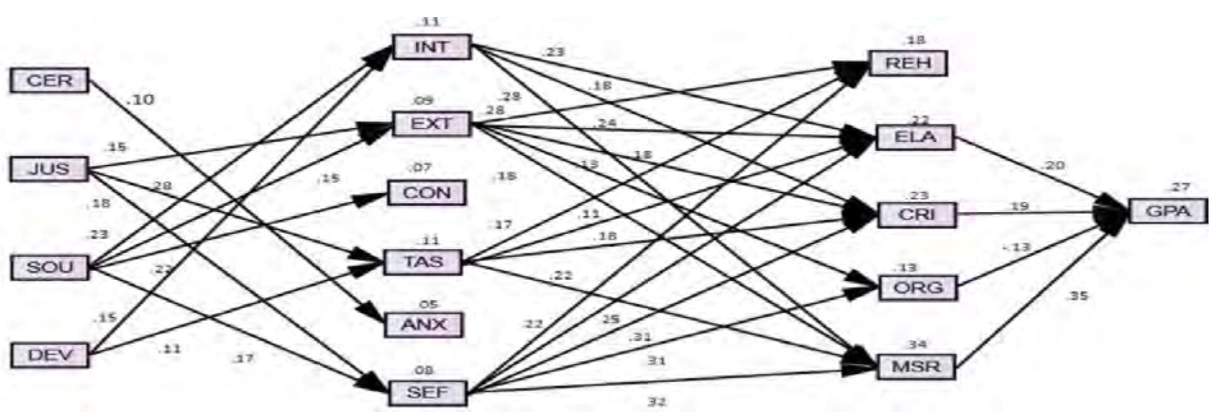

Figure 2. The final structural equation model with standardized beta coefficients.

Table 3. Path coefficients.

Variable	INT	EXT	TAS	CONT	SELF	ANX	REH	ELA	CRI	ORG	MSR	GPA
CER	–.009	–.026	.075	.002	.024	–.101*	**–.015**	**–.005**	**–.010**	**.002**	**–.012**	**–.007**
JUS	.057	.153**	.277**	.024	.179**	.069	**.127****	**.123****	**.144****	**.085****	**.166****	**.097****
SOUR	.227*	.152**	–.002	.222**	.168**	.051	**.083****	**.125****	**.122****	**.076****	**.162****	**.094****
DEV	.153*	.098	.108*	.091	.061	.101	**.057***	**.083****	**.086****	**.041**	**.115****	**.067****
INT							.011	.226**	.177**	–.007	.283**	**.179****
EXT							.276**	.240**	.177**	.129*	.179**	**.123****
TAS							.167**	.106*	.176**	.074	.219**	**.127****
CONT							.017	–.022	.007	.013	.071	**.020**
SELF							.223**	.249**	.308**	.309**	.315**	**.175****
ANX							–.045	.003	.037	.017	.049	**.016**
GPA							–.015	.195**	.193**	–.132**	.354**	
R^2 (%)	11	9	11	7	8	5	18	22	23	13	34	27

Note. Bolded values represent the indirect effect coefficients.
$^{*}p < .05$. $^{**}p < .01$.

learning beliefs, and self-efficacy. In addition, intrinsic goal orientation was positively related to elaboration, critical thinking and metacognition. Also, extrinsic goal orientation and task value were related to more use of rehearsal, elaboration, critical thinking, and metacognition strategies. Although self-efficacy was related to all cognitive and metacognitive strategies, control of learning belief and test anxiety were not related to any cognitive and metacognitive strategies. Science achievement was related to higher usage of elaboration, critical thinking, and metacognition. Yet, organizational strategies were negatively related to science achievement.

Conclusion and implications

In this study, a model that assumed that personal epistemology influence directly students' motivation for achievement and indirectly cognitive and metacognitive strategies through their direct influence on motivation for achievement was proposed and tested.

The results of this study provide evidence that students' ideas about knowledge and knowing influence their motivation for achievement. The results showed that students who had sophisticated beliefs on justification of knowledge- the idea that knowledge comes from reasoning and experimenting-were more self-efficacious, and had more intrinsically motivation toward science. Kizilgunes et al. (2009) reported that students who had a strong belief in the role of evidence tended to have less extrinsic motivation and more intrinsic motivation. Also, Muis and Franco (2009) reported a negative correlation between justification of knowledge and extrinsic motivation. On the other hand, inconsistent with Kizilgunes et al. and Muis and Franco, I found that students with more sophisticated idea on justification of knowledge had extrinsic motivation toward science. A possible reason for this result can be the complex nature of the extrinsic motivation. Although traditionally extrinsic motivation had been negatively associated with learning and achievement, some recent studies showed that extrinsic motivation can be beneficial to learning (Pintrich, 2000). Moreover, extrinsic motivation is driven by achievement motivation (Elliot, 1999).

Ravindran, Greene, and Debacker (2005) demonstrated having a naïve belief about source of knowledge was correlated to less reporting of meaningfully engagement with course materials, on the one hand. One the other hand, Ricco, Pierce, and Medinilla (2010) reported that sophisticated beliefs on source of knowledge were negatively related to intrinsic goal orientation, self-efficacy and task value. In this study it was found that students who had strong beliefs that knowledge is internally constructed (source of knowledge) were more self-efficacious, had more intrinsic motivation, and an internal control of learning beliefs. These students were more likely to feel more confident about their ability and have control on their learning to be successful in science, and study for curiosity and mastery.

Koksal (2011) reported that believing on existence of only one truth was correlated to students' test anxiety on biology learning. Similarly, it was found that beliefs about certainty of knowledge were negatively related to test anxiety in science. Consistent with Koksal (2011), this result indicates that students who believed knowledge is certain had test anxiety on science learning. Kizilgunes et al. (2009) reported that beliefs about certainty of knowledge were negatively related to goal orientations. However, in this study it was found that certainty of knowledge was not related to goal orientations.

Hofer and Pintrich (1997) stated that students' ideas about knowledge and knowing are related to their achievement goals that they established for a learning task. Paulsen and Feldman (2005) demonstrated that students who believed knowledge is simple were less likely to have intrinsic goal orientation, be self-efficacious, appreciate the value of learning task, and perceive internal locus of control on their academic performance. Also, Muis and Franco (2009) reported that viewing knowledge as complex was related to adopting intrinsic goal orientation. Consistent with these results and the predictions, it was found that students who viewed knowledge as complex were likely to study for the reason of mastering course content, and appreciate the value of learning task.

Additionally, it was hypothesized that students' motivations for achievement were correlated to the usage of cognitive and metacognitive strategies they used in learning science and academic achievement. Consistent with previous research and the prediction, self-efficacy was the strongest predictor of cognitive and metacognitive strategies and science achievement (e. g., Al Khatip, 2010; Pintrich & de Groot, 1990). This suggests that self-efficacious students reported more usage of elaborative strategy as well as cognitive engagement, critical thinking, planning, and monitoring strategies, and got a higher GPA through the moderation of cognitive and metacognitive strategies. Likewise, it appears that students who reported to study for the reason of mastering course content demonstrated more use of elaboration, critical thinking and metacognitive strategies. Besides, the results provided evidence for the relationship between extrinsic goal orientation and rehearsal strategy. It is not surprising that students who motivated for demonstrating their ability to their friends and engaged in learning for getting rewards reported more use of rehearsal strategies. Also, these students demonstrated more of planning and monitoring strategies, critical thinking, and science achievement.

One interesting result of this study was that rehearsal strategies were not related to science achievement. In a study with Turkish seventh-grade students, Akyol et al. (2010) reported that use of rehearsal strategy did not statistically significantly predict students' science achievement. The results are consistent with Akyol et al.'s findings. However, studies with Turkish high school students reported that rehearsal strategy was negatively (Yumusak et al., 2007) or positively (Alpaslan, Yalvac, Loving, & Willson, 2015) associated with students' achievement. Although I do not have enough evidence to make such a claim, this suggests that at elementary school level assessments were not merely to measure how well students are at memorizing facts—rewarding the usage of rehearsal strategies—yet, at high school level assessments were negatively or positively related to the use of rehearsal strategy. However, there is a need for further investigation on that how assessments are differentiated at elementary and secondary school levels.

Students with more of planning and monitoring strategies had higher science achievement. Akyol et al. (2010) reported that metacognitive strategies were best predictors of science achievement. Also, Pintrich and De Groot (1990) showed that strategies including metacognition and elaboration were one of best predictors of students' achievement. Consistent with previous research and the prediction, students who set rational goals, did self-testing and self-monitoring, and regulated their learning strategies were more likely to get a higher achievement score. Addition to this, elaboration strategies help students transfer prior knowledge into new knowledge. Thus, it is not surprising that students who connected their prior knowledge into new knowledge by creating analogies and summarizing were likely to succeed in science and result in a higher performance.

Students' personal epistemologies relate to "the goals and standards that determine engagement in learning, depth of processing, and comprehension monitoring" (Hofer, 2001, p. 370). Also, Muis (2007) conceptualized that students' personal epistemologies might indirectly relate to their cognitive and metacognitive strategies. Furthermore, Schommer et al. (2005) stated that students' ideas about knowledge and knowing might be indirectly influence on their learning. In this study I examined the indirect total influence of personal epistemology on cognitive and metacognitive strategies and science achievement. The results of this study provides evidence for the claim that students' views on knowledge and knowing indirectly predicted their cognitive and metacognitive strategies and contributed to their science achievement.

Justification of knowledge relates to how students asses experimenting and reasoning in justifying scientific knowledge claims as important. Considering the results of this study, it is not surprising that beliefs about justification of knowledge indirectly predicted students' cognitive and metacognitive strategies. Students who believed knowledge claims requires evidence, and comes from reasoning and experimenting demonstrated more of elaboration strategy as well as critical thinking, organization, and metacognitive strategies, and performed better in science. It is expected that understanding the role of evidence on theory building contributes students in employing critical thinking skills in learning science. Addition to this, beliefs about source of knowledge were indirectly associated with cognitive and metacognitive strategies. This result suggests that students who viewed scientific knowledge as internally constructed reported more of elaboration strategy, metacognitive strategies, critical thinking, and organization strategy. This is plausible for these students to do self-checking and self-monitoring, and connect their prior knowledge into new knowledge because they viewed neither their teachers nor their textbook as an authority in scientific knowledge construction.

The findings of this study can have practical implications for science teachers and curriculum developers in Turkey. One of important findings of this study is that justification of knowledge was the best predictor of self-efficacy, cognitive and metacognitive strategies, and science achievement. Fostering justification of knowledge can be done by giving argumentation more space in educational practices. Current standards for science education propose argumentation as the central activity of scientists in their scientific practices and students should learn both language and norms for argumentation (National Research Council, 2007). Ryu and Sandoval (2012) stated that argumentation is a social practice that is a particular form of discourse grounded in particular frameworks about what counts as claims, data, justification, and so forth. In this view, argumentation can promote and foster a satisfactory change in how students see reasoning and experimenting in justifying scientific knowledge claims (Dole & Sinatra, 1998). However, research on argumentation reported that students appear to struggle with argumentation (Chin & Osborne, 2010; Ryu & Sandoval, 2012) and that teachers are not comfortable with argumentation (National Research Council, 2007). Thus, teachers should be trained and encouraged to use argumentation in their classrooms.

Another implication of this study is that students' self-efficacy was an important predictor of students' cognitive and metacognitive strategies and their science achievement. As stated in literature and the findings, it is beneficial to foster students' self-efficacy for students to become metacognitive learners and successful in science. One of the source of self-efficacy is students' mastery in their past experience—whether such activities were successes or failures. This suggests that the teachers should consider students' previous experience with the course and encourage them about their ability. Considering the interplays between epistemological predictors of self-efficacy may be beneficial to increase students' self-efficacy level. If the teachers let their students perform their own experiments and observations and encourage them use evidence in their scientific claims, this might help students understand that the answers of scientific questions do not come from authorities and are subject to change, and increase their self-efficacy level.

To generalize the findings of this study, the following points should be approached with caution. First, students' culture influences both personal epistemology and self-regulated learning. Thus, the model may not neatly give the same relations in other countries. Second, only 27% of variance in science achievement could be explained. 73% of it remains unexplained and some other variables in addition to personal epistemology and self-regulated learning seem to be required for expanding the model. Third, in this study, the students' final science grade was taken as their achievement score in science and the researcher does not have any control over the validity of the end of term grade. Fourth, although the four schools were located in the city center in Bursa Province, the participation rate of this study was 51% (322 of 630 students). Last, the questionnaires in this study were originally developed in English and then translated into the language of the students' country. This may lead the cultural sensitivity in the questionnaires to miss out. There is a need for instruments developed by the native speakers of the country.

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